AD-A152 081 STATE OF SOUTH CAROLINA COOPERATIVE AQUATIC PLANT CONTROL PROGRAM(U) CORPS OF ENGINEERS CHARLESTON SC CHARLESTON DISTRICT NOV 80 1/2

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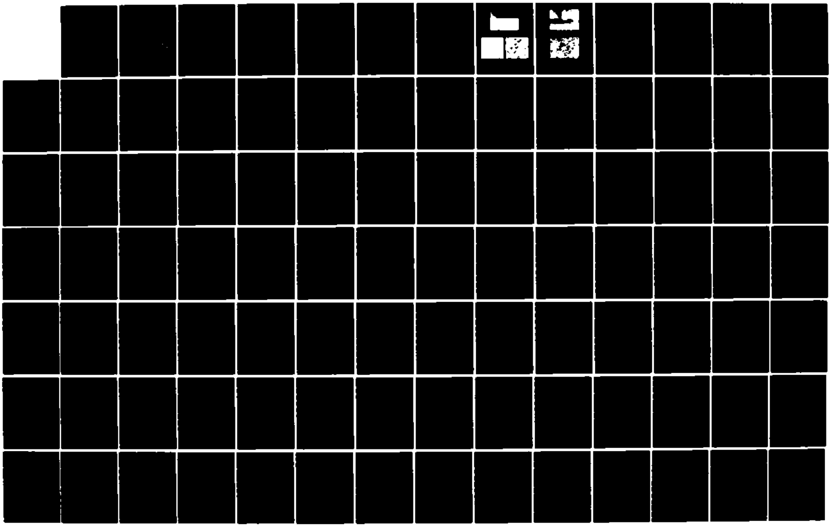

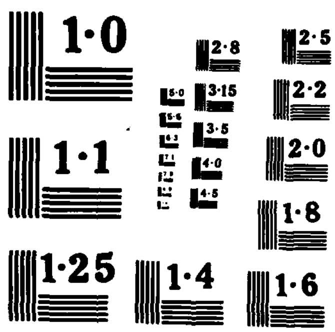
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STATE OF SOUTH CAROLINA

# cooperative aquatic plant control program

## FINAL ENVIRONMENTAL IMPACT STATEMENT





CHARLESTON DISTRICT
U.S.ARMY CORPS OF ENGINEERS

NOVEMBER 1980





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FINAL

ENVIRONMENTAL IMPACT STATEMENT

COOPERATIVE AQUATIC PLANT CONTROL PROGRAM

STATE OF SOUTH CAROLINA

The responsible lead agency is the U. S. Army Engineer District, Charleston, South Carolina.

The responsible cooperating agency is the South Carolina Water Resources Commission.

Abstract: The proposed program provides for a comprehensive plan to control noxious aquatic plants within the state waters of South Carolina in the interest of navigation, flood control, agriculture, fish and wildlife, public health, and other related purposes. Target species include alligator weed (Alternanthera philoxeroides), Brazilian elodea (Egeria densa), and water primrose (Ludwigia uruguayensis). Alligator weed would be controlled by an integrated program involving biological control and herbicides. Brazilian elodea and water primrose would be controlled primarily by herbicides. Other treatment methods acceptable under the recommended plan include mechanical harvesting and fiberglass bottom screens. The selection of treatment methods for individual sites would be the responsibility of the Corps in cooperation with the local sponsor.

The control program has been tentatively selected based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

Send your comments to the District Engineer by

If you would like further information on this statement, please contact:
Mr. John Carothers
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P.O. Box 919
Charleston, South Carolina 29402
Commercial Telephone (803) 724-4258
FTS Telephone: 677-4258

NOTE: Information, maps and plates discussed in the General Design Memorandum No. 3, Aquatic Plant Control Program, State of South Carolina are incorporated by reference in the EIS.

## SUMMARY

### COOPERATIVE AQUATIC PLANT CONTROL PROGRAM

### STATE OF SOUTH CAROLINA

Responsible Office: U.S. Army Engineer district, Charleston South Carolina

( ) Revised Draft (X) Final Environmental Impact Statement

1. Name of Action: (X) Administrative ( ) Legislative

2. Major Conclusions and Findings: The proposed program provides for a comprehensive plan to restore public water bodies in South Carolina to a more natural condition by controlling the excessive growth of aquatic vegetation in the interest of navigation, flood control, agriculture, fish and wildlife, public health, and other related purposes. Target species include alligator weed, Brazilian elodea and water primrose. The State of South Carolina would participate to the extent of 30 percent of the cost of field work. The State's share would probably consist of work in kind in aquatic weed infested areas.

Alligator weed would be controlled by the integrated program involving biological controls and herbicides. Brazilian elodea and water primrose would be controlled primarily by herbicides. Other treatment methods acceptable under the recommended plan include mechanical harvesting and fiberglass bottom screens. The selection of treatment methods in individual sites would be the responsibility of the Corps in cooperation with the local sponsor.

Research for developing new and improved methods of aquatic plant control is also a primary mission of the Corps; most of the research effort is centered at the Corps' Waterways Experiment Station in Vicksburg, Mississippi. Currently, major emphasis in research is in the development of biological controls. New control techniques or procedures which offer some advantage in cost or effectiveness with acceptable environmental impact will be adopted as they may be developed.

3a. Favorable Impacts: The reduction in dense growths of aquatic plants would improve drainage and navigation, reduce potential public health problems by reducing mosquito breeding areas, and improve recreational boating of infested waterways. Removal of aquatic plants would improve fishery habitat by removing excessive cover for forage fish and lessening the possibility of dissolved oxygen depletions. The program would benefit waterfowl by clearing the water surface and by allowing the growth of native aquatic plants having greater food value to waterfowl.

6. Comments Received from Public Review of the Revised Draft Environmental Impact Statement:

| | |
|---|---|
| USDA Soil Conservation Service | 29 April 1980 |
| U.S. Department of Health, Education and Welfare, Public Health Service | 28 May 1980 |
| U.S. Department of the Interior | 29 May 1980 |
| U.S. Environmental Protection Agency | 5 June 1980 |
| S.C. Department of Health and Environmental Control | 16 April 1980 |
| S.C. Water Resources Commission | 24 April 1980 |
| State of South Carolina, Office of the Governor | 30 April 1980 |
| S.C. Department of Parks, Recreation and Tourism | 5 May 1980 |
| S.C. Department of Archives and History | 6 May 1980 |
| Institute of Archeology and Anthropology, University of South Carolina | 8 May 1980 |
| State of South Carolina, State Clearinghouse | 9 June 1980 |

7. Revised Draft Statement Listed in Federal Register on: 8 April 1980

Final Statement Listed in Federal Register on:

## Table of Contents (cont'd)

# 1. NEED FOR AND OBJECTIVES OF ACTION

1.01 General. A program for the control of three species of noxious aquatic plants is proposed for waters within the State of South Carolina. Target species include alligator weed, Brazilian elodea, and water primrose (see figures 1 and 2). Alligator weed would be controlled by an integrated program involving biological controls and herbicides. Brazilian elodea and water primrose would be controlled primarily by herbicides. Other treatment methods acceptable under the recommended plan include mechanical harvesting and fiberglass bottom screens. The selection of treatment methods for individual sites would be the responsibility of the Corps in cooperation with the local sponsor.

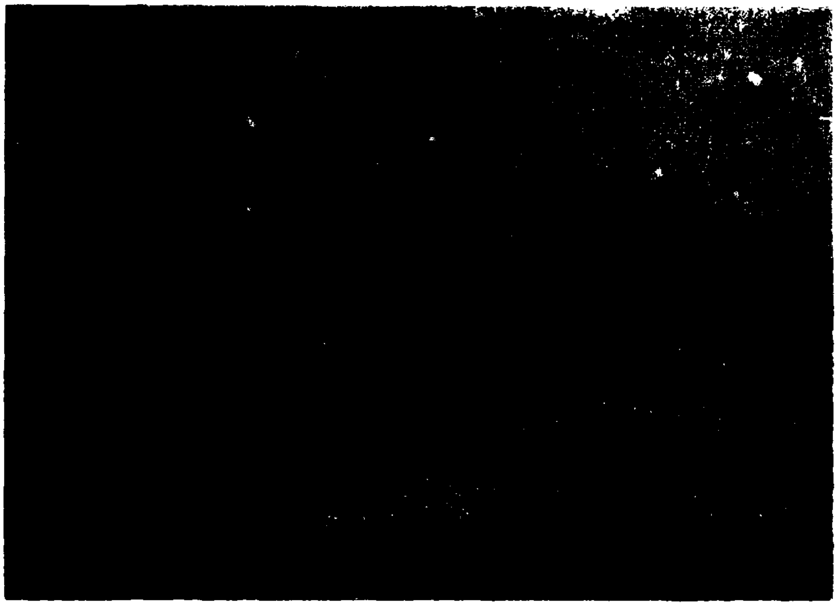
1.01.1 The control program has been selected based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

1.01.2 The South Carolina Water Resources Commission is designated as the State's lead agency for aquatic plant management. The Water Resources Commission has agreed to act as the major sponsor for the program, coordinating with local and state agencies to select treatment methods and provide cost-share funding.

1.02 Study Authority. This program is authorized by the 1958 River and Harbor Act as amended by Section 302 of Public Law 89-298, 89th Congress, approved 27 October 1965 which states as follows: "Section 302 - Section 104 of the River and Harbor Act of 1958 (72 Stat. 297, 300), as amended by Section 104 of the River and Harbor Act of 1962 (76 Stat. 1173, 1180), is hereby further amended to read as follows: Section 104 (a) There is hereby authorized a comprehensive program to provide for control and progressive eradication of water hyacinth, alligator weed, Eurasian water milfoil, and other obnoxious aquatic plant growths, from the navigable waters, tributary streams, connecting channels, and other allied waters of the United States, in the combined interest of navigation, flood control, drainage, agriculture, fish and wildlife conservation, public health, and related purposes, including continued research for development of the most effective and economic control measures, to be administered by the Chief of Engineers, under the direction of the Secretary of the Army, in cooperation with other Federal and State agencies. Local interests shall agree to hold and save the United States free from claims that may occur from control operations and to participate to the extent of 30 percent of the cost of such operations. Costs for research and planning undertaken pursuant to the authorities of this section shall be borne fully by the Federal Government; . . . " Appropriations are limited to $5,000,000 annually. Funds are allocated to the various Districts by the Chief of Engineers on a priority basis, based upon the need in each area and the availability of local funds.

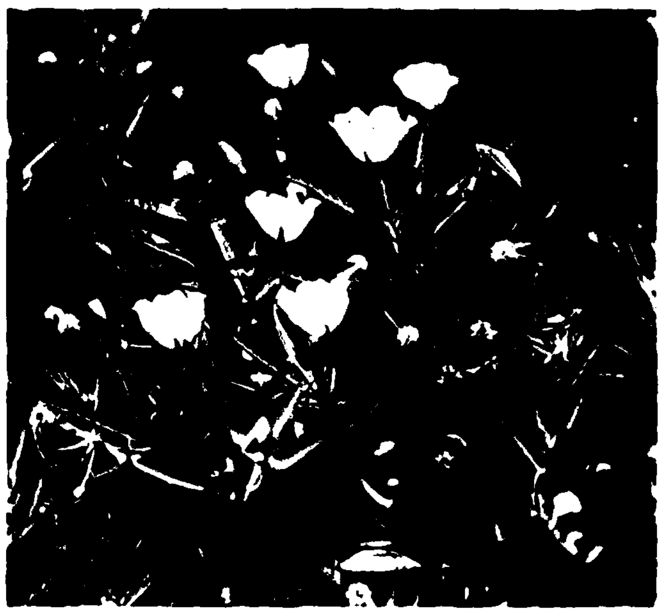
1.03 Public Concerns. Overabundant growths of aquatic vegetation seriously limit the flow of water and interfere with man's recreational activities, navigation, flood control, drainage, agriculture, fish and wildlife conservation, and public health. The full utilization of public waters cannot be realized unless major infestations of aquatic plants are controlled.

1.04 Planning Objectives. The objective of the aquatic plant control program is to control major aquatic plant infestations which interfere with full



**Brazilian elodea and water primrose growths in Lake Marion, 1979**

**Brazilian elodea**
***(Egeria densa)***



**Water primrose**
***(Ludwigia uruguayensis)***

**Figure 1**

**Alligator weed in the North Fork Edisto River**

**Alligator weed *(Alternanthera philoxeroides)***

**Figure 2**

utilization of public waters and to achieve this control by a method or combination of methods that are economically practical, reasonably effective, and environmentally acceptable. A comprehensive program involving biological, chemical, mechanical, and integrated means as well as environmental manipulations may be used in control of the noxious aquatic weeds. Plate 1 shows the major streams and rivers in South Carolina which contain excessive amounts of aquatic plants.

## 2. ALTERNATIVES

2.01 Alternatives Considered. The alternatives considered for aquatic plant control fall into the following basic categories: biological control, mechanical control, chemical control, environmental manipulation, integrated control, and no action. Evaluation of each alternative involved determining the contributions of the alternative to the national planning objectives of national economic development and environmental quality of the Water Resources Council's principles and standards.

2.01.1 Alternative treatment methods were then evaluated with regard to economic, environmental concerns, effectiveness of control, and applicability to potential areas.

2.02 Alternatives Eliminated in Initial Screening. Treatment methods eliminated in the initial screening are listed in Table 1 with the reasons for their elimination.

2.03 Alternatives Considered in Detail. Treatment methods given extensive review for possible use in an aquatic plant management program are shown in Table 2 and summarized below. Detailed cost breakdowns for mechanical harvesting, rotovating, hand removal, fiberglass bottom screens, and chemical treatment alternatives are provided in Appendix D.

2.04 Mechanical Harvesting. Mechanical harvesting entails cutting aquatic vegetation below the water surface and removing the cut vegetation from the water. The root systems are not affected, so the plants continue to grow. Several types of harvesters are available ranging from small cutter boats which require hand pickup of cut plants to large units with automatic loading capability.

2.04.1 Mechanical harvesters are generally ineffective in shallow water areas (0-2 feet) and areas with fallen trees and stumps. Results of a recent study in Lake Jessup, Florida by the Waterways Experiment Station, Corps of Engineers, revealed that 69 percent of aquatic weed infested areas occur in a shallow depth range of 0-2 feet (LaGarde, 1980). Most water bodies infested with aquatic plants in South Carolina are characterized as shallow or tree and stump infested. Approximately 80% of Lake Marion's 97,000 acres were wooded swamplands which were inundated in 1941 without clearing.

2.05 Rotovating. Rotovating involves "tilling" the bottom sediments to a depth of 6 inches to dislodge plant roots. The plant parts float to the surface and are then removed. This method is not 100 percent effective because all of the plants do not float, nor are they always completely removed. Fragments of Brazilian elodea and alligator weed readily root at nodes. Uncollected fragments may float downstream and infest other water areas. Similar to mechanical harvesting, rotovating is ineffective in stump and tree infested areas. Additionally, rotovating produces tremendous disruption of the substrate.

2.05.1 A definite cost per acre for rotovating has not been established. Based upon the Washington State Aquatic Plant Management Program, costs in the range of $600 to $700 per acre, plus capital cost ($50,000) could be expected.

2.06 Hand Removal. Hand removal can consist of either pulling individual plants by hand, which removes the roots, or by using a rake or other tool which would remove only the foliage. This method is obviously limited but can be used to clear around private piers or to remove small patches to prevent spread. Hand removal is mainly restricted to areas less than 4 feet deep.

2.06.1 The cost of this method, which would be based principally on labor would be entirely dependent on the situation. Use of this method would be minimal and very localized. No per-acre cost has been estimated because of lack of data and limited probable use of this method.

Table 1

TREATMENT METHODS
ELIMINATED DURING PRELIMINARY REVIEW

| METHOD | REASON FOR ELIMINATION |
|---|---|
| Chemical: | |
| Silvex | Banned by the Environmental Protection Agency |
| Fenac | Requires drawdown of water body for treatment |
| Endothall (N, N-dimethylalkylamine (DMA)) (Liquid-Hydrothol) | Toxic to fish at concentrations necessary to control elodea/not effective on alligator weed or primrose |
| Dragline | High cost/large environmental disruption (e.g. disruption of substrate)/disposal problems |
| Hydraulic Dredge | High cost/large environmental disruption (e.g. eliminates benthic organisms)/ disposal problems |

2.07 Fiberglass Bottom Screens. Bottom screens involve the installation and anchoring of a polyvinyl chloride-coated fiberglass screen. The screen limits sunlight penetration and effectively eliminates many aquatic growths in affected areas.

2.07.1 Because of the cost of the screen and the fact that it eliminates all vegetative growth, it is justified only for high-use-areas where the exclusion of all aquatic growth is acceptable, such as swimming beaches. The cost and installation of fiberglass bottom screen averages $0.22 per square foot or $9583.20 per acre.

growth, mortality and food habits. Hydrilla is one of the worst aquatic plant problems, and growing conditions in South Carolina appear suitable for its establishment, so this research is potentially applicable to South Carolina.

2.08.5 Other bio-control agents have been investigated in other Corps Districts, but were found to be inefficient, intolerant of the environment in which they would be used, or capable of adversely affecting native ecosystems. Among the bio-control agents investigated were nutria (Myocaster coypus), the manatee (Trichechus manatus), the marisa snail (Marisa connuarietis), Tilapia (Tilapia mossambica), and Northeast disease (a plant pathogen). The manatee has little potential to control aquatic plants because of its low reproductive potential, high mortality due to boat injuries, and intolerance of cold weather. The marisa snail was tried on problem plants, but its low tolerance to cold weather ruled it out as a control agent. Tilapia was tested, but its feeding habits proved to be detrimental to water quality and the aquatic ecosystem. The tilapia, a bottom feeder, disturbs sediment and decaying organic material as it forages, which increases turbidity and decreases dissolved oxygen. Santee-Cooper, S.C. Public Service Authority is currently testing additional species of Tilapia which show promise in controlling submersed aquatic plants. One species in particular, Tilapia zillii, has shown encouraging results. Management of this biocontrol agent is complicated by the fact that Tilapia cannot tolerate the winter temperature experienced in South Carolina. Northeast disease, which decimated Eurasian milfoil in Chesapeake Bay, was tried in the Crystal River area of Florida, but without success. Nutria populations are distributed throughout the Gulf Coast States. Although the animal feeds on aquatic plants, they do not provide effective control.

2.09 Chemical Control. The chemical control method consists of the application of herbicidal material to the plants. Chemical control is generally effective in reducing the problems caused by over-abundant growth of problem plants in a relatively short time. Herbicides would be used in accordance with label instructions and in accordance with Section 2 (7)(ee) of the Federal Pesticide Act of 1978. A detailed description of herbicides which could be used is contained in Appendix C.

2.09.1 2,4-D. The chemical 2,4-dichlorophenoxyacetic acid (2,4-D) is a systemic herbicide registered by the U. S. Environmental Protection Agency (EPA). 2,4-D is very effective in controlling water primrose. Generally two treatments per year should provide adequate control. 2.4-D effectively controls alligator weed by killing leaves and stems of the plant. Three treatments per year are generally required for adequate control, in combination with the alligator weed flea beetle and alligator weed stem borer. Two different formulations of 2,4-D could be used for controlling alligator weed and water primrose: a liquid, dimethylamine salt (DMA); and granular form, butoxyethanol ester (BEE).

(A) Dimethylamine Salt of 2,4-D* (Liquid)

Active Ingredients -
Dimethylamine Salt of 2,4-
Dichlorophenoxyacetic Acid...............49.5%
Inert Ingredients............................50.5%

*EPA Registration Number 39511-64-AA

TABLE 2

ALTERNATIVE TREATMENT METHODS

| | | CHEMICAL | | | | MECHANICAL | | | ENVIRONMENTAL MANIPULATION (CONTINUED) | | BIOLOGICAL (CONTINUED) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONSIDERATIONS | | 2,4-D (DMA & BEE) | ENDOTHALL* | DIQUAT | COPPER COMPLEXES | HARVESTERS | ROTOVATORS | HAND REMOVAL | BOTTOM SHADING | [illegible] | INSECTS |
| FRAGILE OR SENSITIVE ECOSYSTEMS | ADVANTAGES | No disruption of substrate. Selective for alligator weed and water primrose. | No disruption of substrate. | No disruption of substrate. | No disruption of substrate. | Area of treatment is controlled (no impact to non-target area). | Area of treatment is controlled (no impact to non-target area). | Very selective for treatment area. | Very selective for treatment areas. | None | No disruption of substrate. |
| | DISADVANTAGES | Possible impacts with repeated use. Drift may affect nontarget areas. | It is a nonselective herbicide that will destroy other submersed nontarget species that may be mixed with elodea. Drift may affect nontarget areas. | It is a nonselective herbicide that will destroy many nontarget species that may occur in the treatment area. Drift may affect nontarget areas. | Toxicity to phytoplankton and microcrustaceans may occur in the the treatment area. | Non-selective, eliminates habitat, food and cover for a variety of aquatic organisms. May disrupt substrate in shallow areas. | Non-selective, eliminates habitat, food and cover for a variety of aquatic organisms. Disrupts substrate. | Slight disruption of substrate. | Disruption of benthic communities. | Dewatering of the shore zone would kill aquatic plants, benthic organisms, severe disruption to the littoral habitat. | Possi[illegible] form[illegible] adverse interaction with native species. |
| POTABLE WATER SUPPLY | ADVANTAGES | Rapid breakdown results in no long-term interruption of water use. | Rapid breakdown results in no long-term interruption of water use. | Rapid breakdown results in no long-term interruption of water use. | Concentrations used are safe in potable water. | Minimum disruption of water quality. | Short term disruption of water quality. | None | None | None | No disruption of substrate. |
| | DISADVANTAGES | Concentrations must not exceed allowable limits (0.1 ppm) | Cannot use treated water for 7 days after application. | Cannot use treated water for 10 days after application. | Copper complexes are corrosive to metal pipes and pumps. | None | Temporary localized turbidity following treatment. May release bound pollutants from sediments. | Temporary localized turbidity to small areas during treatment | None | Could result in water levels that are below water intakes. Shore erosion resulting from dewatering could cause water quality problems. | None |
| IRRIGATION WATER SUPPLY | ADVANTAGES | Will reduce clogging of intake structures. | Will reduce clogging of intake structures. | Will reduce clogging of intake structures. | Will reduce clogging of intake structures | Will reduce clogging of intake structures | Will reduce clogging of intake structures. | Does not disrupt use of irrigation water | Will reduce clogging of intake structures. | Will reduce clogging of intake structures. | Will reduce clogging of intake structures. |
| | DISADVANTAGES | Cannot use treated water for 14 days after application. | Cannot use treated water for 7 days after application. | Cannot use treated water for 10 days after application. | Copper complexes are corrosive to metal pipes and pumps. | None | Temporary, localized turbidity following treatment. May release bound pollutants from the sediments | None | None | May result in water levels that are below water intakes and less irrigation water supply. | None |
| FISHERIES | ADVANTAGES | Non-toxic to most fish species at concentration used for weed control | Non-toxic to most fish species at concentration used for weed control | Non-toxic to most fish species at concentration used for weed control. | Non-toxic to most fish species at concentration used for weed control. | No possible chronic impacts | No possible chronic impacts | No chronic impacts, temporary small area disturbance | No chronic impacts, temporary small area disturbance. | None | Potential food source for other aquatic organisms. |
| | DISADVANTAGES | Toxicity to some species is unknown. May have chronic effects with repeated use | Toxicity to some species is unknown. May have chronic effects with repeated use | Toxicity to some species is unknown. May have chronic effects with repeated use | Destroys phytoplankton, the base of the fish food chain. May have chronic effects with repeated use. | May have some affect due to non-selective loss of aquatic vegetation. Some direct kill of small fish during harvesting. | Destruction of benthic communities may have adverse effects on other acquatic organisms that feed on the benthos. Non-selective loss of aquatic vegetation | Slight impact due to increased turbidity | Slight impact due to non-selective loss of vegetation. Disruption of benthic communities | Non-selective loss of aquatic vegetation. Dewatering of the shore zone may kill benthic organisms, fish and fish eggs | May adversely affect existing fish food sources. |
| WILDLIFE | ADVANTAGES | Non-bioaccumulative. Concentration level used is below the toxicity of most mammalian and avian species. | Non-bioaccumulative. Concentration level used is below the toxicity of most mammalian and avian species. | Non-bioaccumulative Concentration level used is below the toxicity of most mammalian and avian species. | Non-bioaccumulative. Concentration level used is below the toxicity of most mammalian and avian species. | No possible chronic impacts | No possible chronic impacts | No possible chronic impacts | No possible chronic impacts | May encourage seed producing wetland plants for waterfowl | Potential food source for water fowl and shore birds. |
| | DISADVANTAGES | May have chronic toxic effects with repeated use. | May have chronic toxic effects with repeated use. | May have chronic toxic effects with repeated use. | May have chronic toxic effects with repeated use. | May have minor effects on wildlife due to non-selective loss of vegetation | May have minor effects on wildlife due to non-selective loss of vegetation | None | Slight impact due to non-selective loss of vegetation. | Dewatering of the littoral zone could have adverse impacts on resident and migratory waterfowl and on shore birds that feed and rest in shore zones. | May have adverse impacts on nesting area for shore birds. |
| PERFORMANCE (EFFECTIVENESS) | ADVANTAGES | Quickly kills alligator weed and water primrose stems and leaves. | Effective in controlling elodea | Effective in controlling elodea. Contact herbicide kills stems and leaves only of alligator weed and water primrose. | Combined with diquat, produces a very effective combination to control elodea. Will kill the stems and leaves of alligator weed and water primrose | Effective in removing weeds in water depths 2 to 8 feet deep. Immediate relief. | Effective in removing weeds in water depths greater than 2 feet. Immediate relief. | Useful for small areas and high use area. | Material is reusable, useful for small confined areas and high use areas. Impact localized to the area treated. | Very effective in controlling elodea | Very effective in controlling alligator weed in an integrated control program with herbicides |
| | DISADVANTAGES | Regrowth of alligator weed from underwater stem nodes likely to occur. Not effective on elodea | Not effective control agent for alligator weed or water primrose. | Alligator weed and water primrose will grow back in 4 to 8 weeks. | Alligator weed and water primrose will grow back in 4 to 8 weeks. | Ineffective in shallow waters (less than 2 feet). Regrowth will occur in 4 to 8 weeks. Shore disposal of wet weeds | Ineffective in shallow waters. Cannot operate in rough water. Shore disposal of wet weeds. Regrowth will occur with alligator weed and water primrose. | Very limited in possible scope, labor intensive, very costly. | Not effective in areas with fallen trees and stumps. | Not effective in controlling alligator weed or water primrose. Can only be used in water bodies where the level can be controlled. | Not effective for elodea or water primrose. This method is still being researched. |

* Dipotassium Salt;DMA (Granular)

TABLE 2 (CONTINUED)

ALTERNATIVE TREATMENT METHODS

| | | CHEMICAL | | | | MECHANICAL (CONTINUED) | | | ENVIRONMENTAL MANIPULATION (CONTINUED) | | BIOLOGICAL (CONTINUED) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONSIDERATIONS | | 2,4-D (DMA & BEE) | ENDOTHALL* | DIQUAT | COPPER COMPLEXES | HARVESTERS | ROTOVATORS | HAND REMOVAL | BOTTOM SHADING | WATER LEVEL FLUCTUATION | INSECTS |
| RECREATION (WATER CONTACT AND NONWATER CONTACT) | ADVANTAGES | No long-term recreational restriction. | No long-term recreational restriction. | No long-term recreational restriction. | No restrictions. | No restrictions to recreational use. | No long-term recreational restrictions. | No restrictions to recreational use. | No restrictions to recreational use. | None | No restrictions to recreational use |
| | DISADVANTAGES | Swimming should be restricted for 1 day; fishing should be restricted for 3 days following application. | Swimming should be restricted for 1 day; fishing should be restricted for 3 days following application. | Swimming and fishing should be restricted for 10 days following application. | None. | Swimmers, boaters and water skiers would have to avoid harvesting equipment during harvesting operations. | Could interrupt or congest navigation channel during treatment operations. | Swimmers, boaters and water skiers would have to avoid areas during operation. | Could limit swimming and boating activities during the treatment period. | *Drawdown operations could restrict use of recreational facilities.* | None |
| NAVIGATION | ADVANTAGES | Maintain open channels. | Maintain open channels. | Maintain open channels. | Maintain open channels. | Maintain open channels. | Maintain open channels. | None | Maintain open channels. | None | Maintain open channels. |
| | DISADVANTAGES | None | None | None | None | Could interrupt or congest navigation channel during treatment operations. | Could interrupt or congest navigation channel during treatment operations. | Cost prohibitive. | Could interrupt or congest navigation channel during treatment operations. Cost prohibitive. | Drawdown operations could *adversely affect the depth* of navigation channels. | Not totally effective in completely removing plant debris. |
| HYDROPOWER | ADVANTAGES | *Reduce clogging of water intake.* | *Reduce clogging of water intake.* | *Reduce clogging of water intake.* | *Reduce clogging of water intake.* | Reduce clogging of water intake. | Reduce clogging of water intake. | Reduce clogging of water intake. | *Reduce clogging of water intake.* | *Reduce clogging of water intake.* | *Reduce clogging of water intake.* |
| | DISADVANTAGES | None | None | None | None | None | None | None | None | Drawdown operations could be limited by the location of multi-level intakes. Could affect hydropower capacity. | None |
| HUMAN TOXICITY | | Fairly low toxicity. May have chronic effects with repeated exposure. | Acute and chronic toxicities unknown. | Acute and chronic toxicities unknown. | Acute and chronic toxicities unknown. | None | None | None | None | None | None |
| REGULATORY REQUIREMENTS (Permits, Registration, Licenses, etc) | | Commercial preparations must have an EPA approved label and a registration number. The applicator must be licensed and label restrictions must be followed. | Commercial preparations must have an EPA approved label and a registration number. The applicator must be licensed and label restrictions must be followed. | Commercial preparations must have an EPA approved label and a registration number. The applicator must be licensed and label restrictions must be followed. | Commercial preparations must have an EPA approved label and a registration number. The applicator must be licensed and label restrictions must be followed. | May require Department of Army and State of South Carolina permits for disposing plant material. | May require State of South Carolina water quality permit. | None | None | Permits may be required for drawdown operations. | Federal law requires U. S. Department of Agriculture review and testing of exotic species. |
| ECONOMIC COST | | 2,4-D (DMA) $90 to $138/acre.<br>2,4-D (BEE) $160 to $180/acre. | Liquid $220 to $250/acre.<br>Granular $290 to $310/acre. | $200 to $230/acre. | $60/acre. | $360/acre ($160,000 capital cost) includes three cuttings per year. | $600 to $700/acre ($50,000 capital cost). | Labor intensive and expensive. Actual costs dependent upon situation. | $9,563.20/acre installed. | Cost estimates have not been developed. | This method is still being researched. No cost estimates have been developed. |

* Dipotassium Salt;DMA (Granular)

2.09.2.2 The recommended application rate for the liquid form is approximately 5 gallons per acre. The per-acre cost for the chemical and application is $220 to $250 per acre. The recommended application rate for the granular form is approximately 100 pounds per acre. The per-acre cost for the chemical and application is $290 to $310 per acre.

2.09.3 Diquat. The chemical diquat dibromide is a contact herbicide registered by EPA. Diquat kills the leaves and stems of aquatic plants but does not affect plant roots.

Active Ingredients
Diquat dibromide (6,7-dihydrodipyrido (1,2-a: 2,'1'-C) pyrazinediium dibromide................35.3%
Inert Ingredients.............................64.7%

EPA Registration Number 239-1663-AA

2.09.3.1 The recommended application rate for diquat is two gallons per acre. The per-acre cost for the chemical and application is $200 to $230 per acre.

2.09.4 Copper Complex. Chelated copper complexes registered by the EPA may be used in conjunction with diquat. A combination of diquat and a chelated copper tends to produce a synergistic effect enhancing the herbicidal activity of the two herbicides.

Active Ingredients -
Cooper as elemental*....................9.0%
Inert Ingredients...........................91.0%

EPA Registration Number 8959-10AA
*From mixed Cooper Ethanolamine complexes

2.09.4.1 The recommended application rate for the copper compound (Cutrine) is two gallons per acre. The per-acre cost for the chemical is $60 per acre.

2.10 Integrated Control. Integrated control involves a combination of biological controls (insects) and herbicidal spraying. Field work on alligator weed has shown that a combination of biological (flea beetles and stem borers) and chemical (2,4-D) control methods is more effective than either method alone. The integrated control approach is a multi-year program based on reducing early season growth of alligator weed with herbicides during the first year. As alligator weed begins regrowth, bio-control insects are released to provide season-long control. Early spring surveys would be made during succeeding years to determine the degree of alligator weed reduction. If reduction is satisfactory, bio-control agents would again be released if the overwintering population is too low. If reduction is not satisfactory, then first year procedures would be repeated. A usable integrated control program has not yet been developed for other aquatic plants.

2.11 Environmental Manipulation. Each plant species has a requirement for certain environmental conditions in order to survive. Artificial limitation or manipulation of environmental conditions can therefore be used to control the growth of certain plants. Elimination of emergent plants such as cattails or water lilies in shallow water areas can be accomplished by increasing the water depth until the plant is unable to grow. Likewise, fluctuation of water levels in impoundments can be an effective tool in the fluctuation zone.

2.11.1 Environmental manipulation is usually impractical in flowing streams and rivers. However, it does offer the potential of aquatic plant control in impoundments which can be manipulated by periodic drawdown. Drawdowns often conflict with other water uses and may not be practical unless the benefits of aquatic plant control exceed the losses or damages caused by a drawdown. It appears that a drawdown of the Santee Cooper lakes for aquatic plant control would cause an unacceptable loss of power-generating capacity, the primary purpose of the Santee Cooper Project, so that the use of such a drawdown appears impractical. To be effective, drawdowns must coincide with favorable weather conditions.

2.12 No Action. Termination of all active aquatic plant control operations would result in a tremendous adverse impact on the environment and man's use of it. Favorable growing conditions in the Charleston District would encourage the rapid growth and spread of nuisance aquatic plants in the streams, rivers and Santee-Cooper lakes.

2.12.1 This alternative would not affect the activity of the flea beetle and the stem borer which have established reproducing populations. The insects would continue to partially control alligator weed. However, Brazilian elodea and water primrose, for which no biological control agents are developed, would continue to spread. If these noxious aquatic plants are allowed to grow uncontrolled for several years, many waterways could become completely obstructed during most of the year and practically inaccessible to man. All forms of waterborne navigation would be curtailed in these areas. The recreation potential, which includes boating, fishing, swimming, and water skiing, would be significantly reduced.

2.12.2 The flood hazard to low lying areas would be increased by the reduced flow capacity of rivers, streams, and drainage canals. The utilization of renewable resources, such as commercial fishing and recreational sport fishing, would be sharply curtailed. Areas popular for fishing and waterfowl hunting would become inaccessible by boat.

2.12.3 Favorable mosquito-breeding habitat would be created by increased aquatic plant growth, with subsequent increases in the production of disease vector and pest mosquitoes. Mosquito abatement and control programs would have to be expanded to compensate for termination of the aquatic plant control program.

2.12.4 The natural aquatic ecosystem would be adversely affected by the no action alternative. The growth of indigenous vegetation would continue to be depressed by the more competitive exotic species. Plant community diversities would be reduced. Likewise, populations of many small animals which are associated with diverse species of vegetation would also be reduced. The natural aquatic environment, which is typified by a wide variety of plants and animals, would be altered to one supporting a dominant exotic aquatic plant and the fauna capable of existing in this habitat.

## 3. AFFECTED ENVIRONMENT

3.01 Environmental Conditions. The affected environment of this continuing project involves the public waters of the entire State of South Carolina. The

project involves any river, lake, stream, or waterway in the state where aquatic plant infestation is of major economic significance. For the purpose of planning and control operations, the state has been divided into four major river basins which occur within the project bounds. They include all or portions of: Pee Dee Basin, Santee-Cooper Basin, Edisto-Combahee Basin, and Savannah Basin (see Plate 2). In general, however, infestations of noxious aquatic plants are found in the area between the fall line and the upper limits of salt water intrusion. Most control operations would be confined to this area. Individual environmental elements of the state are diverse and are discussed below.

3.02 Geology. Most noxious aquatic plants occur within the Atlantic Coastal Plain Physiographic Province. The topography of this area is characterized by low hills, terraces and plains intersected by southeasterly trending rivers, often with side swamp flood plains. The entire area is underlain by the Black Mingo Formation of Lower Eocene Age, which is composed of an upper zone of red sands and clays and a lower zone of interbedded gray to black sands, shales and limestones. It outcrops north of the Santee River along Black Creek and has a maximum thickness of about 250 feet. The overlying formation is the Santee Limestone which is exposed west of Lakes Moultrie and Marion. The underlying formation is the Pee Dee of Cretaceous Age. The regional strike of the Black Mingo is nearly east-west with a very low dip toward the south. Very little geologic data has been published on the area and the detailed stratigraphy of the region has yet to be worked out.

3.03 Land Resource Areas. Six major land resource areas occur in South Carolina. A description of each land resource area follows. Plate 3 delineates the land resource areas.

3.03.1 Blue Ridge. The Blue Ridge is in the northwestern part of the Charleston District. It adjoins the Southern Piedmont and extends from the southwest to the northeast. The elevation ranges chiefly between 1,200 and 4,000 feet. The rocks consist chiefly of schists and gneisses that have been strongly metamorphosed, folded, and faulted. Topography is generally steep to very steep with narrow, rounded ridgetops that are sloping to strongly sloping. Soils are predominantly thin and stony. The climate is temperate with a 200-day growing season. The streams coursing through this region are cold water, relatively high velocity waterways of narrow widths with predominantly gravel bottoms.

3.03.2 Southern Piedmont. The Southern Piedmont extends across the District in a continuous belt 100 to 115 miles wide, lying between the Blue Ridge and the fall line. The elevation ranges from about 300 to 1,200 feet. Geologically the Southern Piedmont is a dissected peneplain containing a few remnants of an ancient mountain range. The topography is gently sloping to moderately steep with broad to narrow ridgetops. Stream valleys are generally narrow. Swift flowing, cold water streams merge to form more gently flowing, warmer waterways. The gently sloping uplands have deep soils, some of which have good agricultural quality. The narrow stream valleys, typically in woods or brush, have thinner soils or are rocky. The area includes some steeply sloping areas, principally along stream valley walls, where soils have undergone moderate to severe erosion and existing vegetative cover plays a vital role in preventing further erosion and siltation. Piedmont rocks are granites, felsic to mafic schists, phyllites, and granitic and mafic gneisses. The climate is temperate with a 200- to 240-day growing season and an average annual precipitation of 44 to 60 inches.

3.03.3 Carolina-Georgia Sandhills. The Sandhills extend across the District adjacent to the fall line as a discontinuous or irregularly shaped belt from 5 to 30 miles wide. Elevations generally range from 250 to 600 feet. The climate is temperate with a 200- to 240-day growing season and an annual precipitation of about 44 inches. The soils are generally developed from unconsolidated sands, are excessively drained, and have undergone slight to moderate erosion. Stream channels are wider and present a flatter profile as the topography becomes more level.

3.03.4 Southern Coastal Plain. The Southern Coastal Plain extends from southwest to northeast across the District in an irregularly shaped belt 10 to 40 miles wide. It lies generally between the Sandhills and the Atlantic Coastal Flatwoods plain. Elevations range from about 200 to 500 feet. Topography is nearly level to moderately sloping. The climate is warm temperate with a 220- to 250-day growing season and an average annual precipitation of about 46 inches. The area contains some of the District's best farmland. These Class I lands account for approximately 8 to 16 percent of the total area on a county-by-county basis. Bordering the major streams are broad bottomlands which often are seasonally flooded and serve as important water storage and aquifer recharge areas.

3.03.5 Atlantic Coast Flatwoods. The Atlantic Coast Flatwoods is an area that is nearly level and is dissected by many broad, shallow valleys with meandering stream channels. Elevations range from about 40 to 125 feet with local relief of a few feet to about 20 feet. About one-half of the area is forested with the remainder being dominantly cropland. The soils are moderately well to poorly drained and formed in sandy to clayey Coastal Plain sediments. This area occupies 5,585,000 acres or about 29 percent of the state.

3.03.6 Tidewater Area. The Tidewater Area is an area that is nearly level and dissected by many broad, shallow valleys with meandering stream channels. Most of the valleys terminate in estauries along the coast. Elevations range from sea level to about 40 feet and local relief is usually less than 5 feet. About two-thirds of the area is forested. The remainder of the area is marsh, pasture or cropland. The soils are dominantly somewhat poorly to very poorly drained and formed in sandy to clayey Coastal Plain sediments. This area occupies 1,764,000 acres or about 9 percent of the state.

### 3.04 Climate

3.04.1 Temperatures. South Carolina enjoys a relatively mild climate. Summers are warm and humid except where terrain or nearness to the ocean offer relief. From late fall to mid-spring, weather changes are frequent. During winter one to four cold waves usually occur with night temperatures of 20 degrees or lower in the central and upper section of the state. However, the cold periods are usually brief and winters are comparatively temperate. Except in the mountains, temperatures of zero or below are extremely rare.

3.04.2 Precipitation. Except in the mountains, rainfall distribution is fairly even. Rains are least frequent along the coast. Frequency increases gradually as one approaches the mountains. Here the increase is greatest due, in the main, to orographic lifting. The interior of the coastal plain does, however, show a higher frequency of summer showers than other areas. Average annual rainfall varies from 80 inches in the Blue Ridge area to 38 inches in sections of the Southern Coastal Plains LRA.

3.04.3 Growing Season. The growing season is defined as the period between the last freezing temperature in spring and the earliest freezing temperature in fall. The state growing season ranges from 290 days in the Tidewater Area to 200 days in the Blue Ridge Mountains.

3.05 Fish and Wildlife Resources. Fish and Wildlife resources are diverse and are discussed in detail in Appendix A.

3.06 Noxious Aquatic Plant Reconnaissance Survey. Appendix B contains the reconnaissance survey of noxious aquatic plants for the State of South Carolina.

3.07 Significant Resources. All the waters of the state of South Carolina are considered as a significant resource. Additionally, the native flora and fauna inhabiting these waters are deemed as significant resources. Excessive growths of noxious aquatic plants in any river or public waterway within the state hinders the use and maintenance of these basic resources.

3.07.1 Cultural Resources. A search of the National Register of Historic Places revealed many sites within the state of South Carolina, but none that would be affected by any of the recommended alternative aquatic plant control activities.

3.07.2 Threatened and Endangered Species. The Endangered Species Act of 1973 (PL 93-205) establishes two categories of endangerment:

Endangered Species. Those in danger of extinction throughout all or a significant portion of their range.

Threatened Species. Those likely to become endangered within the foreseeable future throughout all or a significant portion of their range (U. S. Department of Interior, 1974).

3.07.2.1 The Federal endangered species list as of August 1979 includes the following species which may or do occur in the State of South Carolina:

SOUTH CAROLINA

(E=Endangered; T=Threatened;)

| Mammals | General Distribution |
|---|---|
| Cougar, Eastern (*Felis concolor cougar*) - E | North, East |
| Manatee, Florida (*Trichechus manatus*) - E | Coastal Waters |
| Panther, Florida (*Felis concolor coryi*) - E | South, West |
| Whale, blue (*Balaenoptera musculus*) - E | Coastal Waters |
| Whale, finback (*Balaenoptera physalus*) - E | Coastal Waters |
| Whale, humpback (*Megaptera novaeangliae*) - E | Coastal Waters |
| Whale, right (*Eubalaena* spp. (all species)) - E | Coastal Waters |
| Whale, sei (*Balaenoptera borealis*) - E | Coastal Waters |
| Whale, sperm (*Physeter catodon*) - E | Coastal Waters |
| **Birds** | |
| Eagle, bald (*Haliaeetus leucocephalus*) - E | Entire State |
| Falcon, American peregrine (*Falco peregrinus anatum*) - E | Northwestern mountains |

Birds (cont'd)

| | |
|---|---|
| Falcon, Arctic peregrine (*Falco peregrinus tundrius*) - E | Coast, western mountains |
| Pelican, brown (*Pelecanus occidentalis*) - E | Coast |
| Warbler, Bachman's (*Vermivora bachmanii*) - E | East, South |
| Warbler, Kirtlands' (*Dendroica kirtlandii*) - E | East, North |
| Woodpecker, ivory-billed (*Campephilus principalis*) - E | East |
| Woodpecker, red-cockaded (*Picoides dendrocopos borealis*) - E | Entire State |

Reptiles

| | |
|---|---|
| Alligator, American (*Alligator mississippiensis*) - T | Coastal Areas |
| Alligator, American (*Alligator mississippiensis*) - E | Inland coastal plain |
| Snake, eastern indigo (*Drymarchon corais couperi*) - T | Extreme Southeast |
| Turtle, Kemp's (Atlantic) ridley (*Lepidochelys kempii*) - E | Coastal Waters |
| Turtle, green (*Chelonia mydas*) - T | Coastal Waters |
| Turtle, hawksbill (*Eretmochelys imbricata*) - E | Coastal Waters |
| Turtle, leatherback (*Dermochelys coriacea*) - E | Coastal Waters |
| Turtle, loggerhead (*Caretta caretta*) - T | Coastal Waters |

Fishes

| | |
|---|---|
| Sturgeon, shortnose (*Acipenser brevirostrum*) - E | Atlantic seaboard rivers |

Plants

| | |
|---|---|
| Bunched arrowhead (*Sagittaria fasciculata*) - E | Greenville County |
| Persistent trillium (*Trillium persistens*) - E | Tallulah-Tugaloo River system, Oconee County |

3.07.3 Prime and Unique Farmlands. The USDA, Soil Conservation Service lists many soil series which are classed as prime and unique farmlands.

## 4. ENVIRONMENTAL EFFECTS

4.01 Environmental Impact. The principal impact of the proposed action would be the reduction of excessive growths of noxious aquatic plants in the waterways of the State of South Carolina. Aquatic plant control is particularly important to man's continued use of the aquatic environment. It should be noted that not all of the impacts listed would occur in every aquatic plant control activity. The impacts would vary with different plants, chemicals, methods of application, climatic conditions, etc.

4.01.1 The control program would remove a serious obstacle to navigation. Removal of aquatic plants would result in a favorable impact on the economic and recreational boating interests.

4.01.2 The control program prevents vegetation from choking drainage canals and diversion channels, thereby increasing water-carrying capacity, and from obstructing water-control structures necessary for flood control. Heavy concentrations of aquatic plants can choke narrow channels or accumulate around bridges and impede water flow to the extent of contributing to overbank flooding.

4.01.3 The control of dense aquatic surface vegetation would reduce the habitat suitable for the breeding of various pest insects. Insect vectors of diseases, such as malaria and encephalitis, are often harbored in aquatic plant growths.

4.01.4 The control program benefits waterfowl by clearing the water surface and by allowing the growth of native plants having greater food value.

4.01.5 Water intake structures, screens, strainers, and pumps in bodies of water with a heavy aquatic plant infestation are often clogged with the plants. The control program eliminates or sharply reduces maintenance costs on such structures.

4.01.6 The control program for such non-native plants as alligator weed and Brazilian elodea benefits the aquatic environment by permitting the establishment of desirable species and by creating favorable conditions for restoration of naturally balanced aquatic ecosystems.

4.01.7 A temporary reduction in water quality results from addition of herbicides to an area heavily infested with noxious aquatic plants. The spray application of 2,4-D to alligator weed and water primrose is done in such a manner that practically all of the chemical remains on the plant. A small amount may reach the water during application or be carried by transport through the plant and out the roots, or be released as the plants die and decompose. The decomposition of aquatic plants killed by herbicides begins shortly after treatment and the rate varies with air and water temperatures. The dissolved oxygen levels of water treated with herbicides would be lowered during the decomposition phase of dead plant material. However, it should be noted that dense mats of aquatic vegetation also cause dissolved oxygen depletions. Principal factors affecting oxygen levels in the water following herbicidal treatment include: amount of plant material involved, oxygen levels before treatment, water depth, plant species decomposition rate, oxygen used by aquatic organisms, water temperature, and rate of flow. As the temperature of water increases, the decomposition rate increases, but its oxygen-holding capacity decreases. As the water temperature decreases, not only does its oxygen-holding capacity increase, but also fish respiration and oxygen demand decreases. Therefore, large, dense stands are only partially treated during warm weather when full treatment could cause considerable fish mortality. Partial treatment or treatment during cooler weather will result in better water quality following treatment. Detritus from the decaying plants falls to the bottom, causing organic buildup. However, these conditions are temporary.

4.01.8 Dense weed cover interferes with a favorable predator-prey balance. Small fish hide in extensive growths, thus avoiding their predators. Ultimately, the fish yield drops and the stunting of fish such as bluegill may occur. A decrease in weed cover can cause increased predation, resulting in an increased growth rate for predator and forage species alike. Clear bottom areas are important as spawning grounds for bass and related panfish (bream and crappie). Thus, aquatic plant control serves to create more suitable nesting areas for the important warmwater game fish. From the fisherman's standpoint, aquatic plant control increases the amount of fishable water and reduces the fouling of tackle and entangling of hooked fish.

4.01.9 Extensive aquatic plant growths impede light penetration and tie up nutrients in the water column to the detriment of the ecosystem. Since live aquatic weeds are grazed very little by primary consumers, the food chain is inefficient.

4.01.10 Removal of these aquatic plants releases the bound nutrients, making them available for phytoplankton blooms. Phytoplankton blooms have been shown to stimulate zooplankton population growth and thereby increase total fish production. Other invertebrates such as insect larvae are generally not affected by aquatic plant control activities, but, when changes do occur, the community typically has more individuals of fewer different types.

4.01.11 The use of herbicides in aquatic plant control activities has raised concern regarding possible adverse environmental impacts. Herbicides are less harmful to aquatic organisms than other groups of pesticides such as insecticides. The majority of herbicide applications result in no significant harm to fish life, due to the wide margin between field concentrations and acute toxicity levels for fish. Only herbicides certified by the Environmental Protection Agency would be used and application would be in accordance with label instructions. A herbicide is certified only after exhaustive testing has demonstrated that its use would be environmentally acceptable. A detailed description of herbicides used is contained in Appendix C.

4.01.12 Another favorable characteristic of most of these chemicals is the rapid disappearance of residues. The herbicides are generally rapidly absorbed by plants and mud and may be decomposed by bacteria. Bioaccumulation has not been found to be a problem in the use of aquatic herbicides.

4.01.13 A temporary decline in phytoplankton has been reported after aquatic plant control with herbicides, and post-treatment increases often occur. Due to the fast growth rate and high species diversity in microscopic algal communities, generally no permanent harm to phytoplankton or periphyton is associated with chemical weed management. Important invertebrate fish food organisms are not usually affected by applications of most herbicides. Laboratory tests have shown that crustaceans are more sensitive to herbicides than aquatic insects.

4.01.14 Spray drift is a potential problem in areas where susceptible crops (cotton, soybeans, peanuts, etc.) or ornamentals are near the area to be treated. Significant damage to such plants is considered unlikely due to the limited amount of spraying in such areas and the use of standard precautionary measures, such as the discontinuance of spraying when wind speed exceeds four mph. Spray additives can be used in extremely sensitive areas to minimize spray drift.

4.01.15 The mechanical control method would be confined mainly to maintaining open boat channels and small harbors. The use of mechanical control equipment would be limited because of vast amounts of shallow, stump infested waters. Plant material cut and not harvested would remain in the water to decompose. This may cause a temporary decrease in dissolved oxygen in the immediate work area. Additionally, plant fragments left after cutting may serve in spreading the plant to adjacent sites.

4.01.16 The project does not appear to have any potential for significantly affecting any endangered or threatened species. Herbicides are certified by the Environmental Protection Agency only after exhaustive testing indicates their use would cause no unacceptable environmental impacts. The purpose of the project is to maintain public waters in a more natural condition by controlling excessive growths of non-native vegetation. This habitat restoration should not significantly affect any endangered species.

4.01.17 From a social standpoint the only impacts would be beneficial because aquatic plant control activities would permit the continued use of water resources for recreational activities.

4.01.18 No structures, sites, or areas listed in the National Register of Historic Places would be affected by this project.

4.01.19 None of the control alternatives should have any effect on prime or unique farmlands.

## 5. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS

5.01 Chemical Control. Application of chemicals to dense growths of problem plants may result in a temporary deterioration in water quality. The decay of large numbers of the plants result in an organic buildup in bottom sediment, a recycling of excessive amounts of nutrients into the water, and a temporary reduction in the amount of dissolved oxygen available for other aquatic life.

5.01.1 Sport fishing in the immediate vicinity of treated aquatic plants may temporarily be adversely affected because certain species of fish avoid water containing chemicals such as 2,4-D.

5.01.2 Some unavoidable damage to beneficial, non-target vegetation may occur. However, control of non-native vegetation would favor the long-term establishment of more beneficial native vegetation.

5.01.3 Habitat for a variety of aquatic organisms and shelter for small fish would be lost due to chemical treatment. This impact would be greater for endothall and diquat because they are non selective and would kill a wide variety of aquatic plants.

5.02 Mechanical Harvesting. Mechanical harvesting is completely nonselective. Nontarget vegetation would be cut in the treatment area. It would eliminate habitat for a variety of aquatic microflora and fauna, aquatic invertebrates, and shelter for small fish. Also, a small number of fish may be lost due to entanglement with the aquatic plants during removal.

5.02.1 Minor adverse impacts to air quality would result from exhaust emissions from mechanical harvesters and trucks used to haul harvested aquatic plants to disposal sites. The mechanical harvesters and trucks would also increase the local noise levels during operation.

5.03 Fiberglass Bottom Screens. Bottom screens would result in the decomposition of plant material in the water. The decomposition would cause a decrease in the dissolved oxygen level. Both target and nontarget aquatic plant species would be killed by bottom shading, eliminating habitat for aquatic organisms and shelter for small fish. The benthic organisms would be made unavailable to the food chain.

5.04 Hand Removal. Hand removal could result in a slight increase in turbidity and a small loss of habitat for aquatic organisms.

## 6. LIST OF PREPARERS

The following people were primarily responsible for preparing this Environmental Impact Statement.

| Name | Expertise | Experience | Professional Discipline |
|---|---|---|---|
| Mr. John Carothers | Botany<br>Fishery Management<br>Wildlife Management | 3 years, fisheries biologist, Alabama Conservation Department | Fish and Wildlife Biologist |
| | | 3 years, fisheries biologist, U. S. Fish and Wildlife Service | |
| | | 5 years, biologist, New Orleans District | |
| | | 9 years, environmental studies, Charleston District | |
| Mr. James Preacher | Botany<br>Fishery Management<br>Wildlife Management | 5 years, soil conservationist, USDA, SCS | Fish and Wildlife Biologist |
| | | 4 years, biologist/botanist, SCS, Columbia, S. C. | Botanist |
| | | 2 years, biologist, Charleston District | |

## 7. COORDINATION

Consultation on Resource Impact. During the review of the Draft Environmental Impact Statement (DEIS), the following agencies submitted comments and suggestions on the potential impact of the program on specific resources. These comments and suggestions were considered in the preparation of the Revised Draft Environmental Impact Statement (RDEIS). Agencies consulted included:

Forest Service, USDA
Soil Conservation Service, USDA
Environmental Protection Agency

Pee Dee Development and Planning Commission
Waccamaw Regional Planning and Development Council
S. C. Wildlife Federation
Columbia Audubon Society
Sierra Club, John Bachman Group
S. C. Environmental Action, Inc.

Coordination of the Revised Draft Environmental Impact Statement. A Notice of Intent to Prepare the Revised Draft Environmental Impact Statement (RDEIS) for an Aquatic Plant Control Program in South Carolina was published in the Federal Register on 16 August 1979. The RDEIS was listed in the Federal Register on 8 April 1980. Copies of the RDEIS were sent out for comment to all Federal, State, and local agencies which have jurisdiction by law or special expertise with respect to any environmental impact involved, or which are authorized to develop and enforce environmental standards, or any agency or organization which has requested that it receive statements on actions of the kind proposed. Copies were also sent on request to interested individuals and organizations.

Eleven letters containing 26 pages of comments and exhibits on the revised draft EIS were received from the following state and federal agencies.

| | Agency | Date |
|---|---|---|
| 1. | U.S.D.A. Soil Conservation Service | 29 April 1980 |
| 2. | U.S. Department of Health, Education, and Welfare, Public Health Service | 28 May 1980 |
| 3. | U.S. Department of the Interior | 29 May 1980 |
| 4. | U.S. Environmental Protection Agency | 5 June 1980 |
| 5. | S.C. Department of Health and Environmental Control | 16 April 1980 |
| 6. | S.C. Water Resources Commission | 24 April 1980 |
| 7. | State of South Carolina, Office of the Governor | 30 April 1980 |
| 8. | S.C. Department of Parks, Recreation and Tourism | 5 May 1980 |
| 9. | S.C. Department of Archives and History | 6 May 1980 |
| 10. | Institute of Archeology & Anthropology, University of South Carolina | 8 May 1980 |
| 11. | State of South Carolina, State Clearinghouse | 9 June 1980 |

The comments which were received on the Revised Draft EIS are summarized in the following paragraphs. Copies of the letters of comment are contained in Appendix F.

U.S.D.A. - Soil Conservation Service

Comment: The EIS has adequately covered the proposed Plant Control Program. We support this program. Page 9 of the EIS discusses Land Resource Areas. Recently a sixth has been delineated. See the attached page.

Response: A sixth Land Resource Area has been added in the final EIS.

Department of Health, Education, and Welfare - Center for Disease Control

1. Comment: We agree that excessive growths of aquatic plants may have to be controlled. However, we have some concern regarding the use of 2,4-D in the aquatic environment. Until more information is known about its chronic effects upon nontarget food chain organisms and potential long-term health risks, the use of 2,4-D should be minimized and if possible restricted to highly infested areas where other control measures are non-effective.

Response: To date 2,4-D is the most effective herbicide registered by EPA for controlling alligator weed and water primrose. In the proposed program, 2,4-D would be applied only as a foliar spray at the rate of four pounds active ingredients per acre. The spray application of 2,4-D would be done in such a manner that practically all of the chemical would remain on the target plants. A small amount of 2,4-D may reach the water during application or be carried by transport through the plant and out the roots, or be released as the plants die and decompose. A detailed description of 2,4-D and its effects on the environment is discussed in Appendix C.

2. Comment: We believe that other control measures such as physical, mechanical and particularly biological controls should be further encouraged. Where access is obtainable and where fragmentation will not threaten uninfested waters, harvesting could remove the plants from the aquatic system and preclude re-entry of decomposed products providing nutrients for future vegetative growth. An integrated control effort which combines both mechanical harvesting and chemical treatment can often be effective. 2,4-D is often most effective when applied to vegetation which is rapidly growing. This rapid growth condition can occur after mechanical harvesting. Would such an integrated control effort using both mechanical harvesting and chemical treatment be applicable in certain infested areas for the target vegetation?

Response: Numerous control measures including biological, physical, chemical, environmental manipulation, integrated and various mechanical methods were explored during the planning process. Following an evaluation of economic and environmental considerations as well as effectiveness a decision was made to use a combination of chemical, biological and integrated control methods as the primary control methods. Additionally, mechanical and environmental manipulation methods may be used in special high use areas.

The Corps' Waterways Experiment Station has an ongoing research program for developing biological control methods. As new bio-control agents are proven effective on target species they will be incorporated into the aquatic plant control program.

3. Comment: The use of rotovating methods, containment booms, suction d[illegible], [illegible] removal, bottom screens, fragment barriers and spread prevention programs to control the target vegetation from spreading may be other measures worth considering. The possible forage and compost benefits of the target vegetation should be assessed in the EIS. Other potential uses of the target vegetation should be considered.

Response: The control methods mentioned are discussed in detail in the final EIS. Forage and compost benefits of target species present an attractive alternative for utilizing harvested plants. Unfortunately the bulk of nuisance aquatic plants in South Carolina are located in waters inaccessible to mechanical harvesters. Shallow waters and tree and stump infested waters preclude the use of mechanical cutters and harvesters.

4. Comment: The EIS should describe the potential beneficial and adverse impacts of using 2,4-D upon sensitive ecosystems, potable water supplies, irrigation waters, fisheries, and wildlife. The effectiveness and proposed application rate of 2,4-D in controlling each of the target vegetation (roots, stems and leaves) in both quiet and turbulent water areas should be noted. This is important because G. E. Smith (Hyacinth Control Journal, 9(1):23-25, 1971) has found 2,4-D to be ineffective in controlling certain vegetation along main river and lake areas where downstream flow or turbulent water rapidly dissipates the herbicide. Please indicate the rate of reinfestation and/or regrowth for each of the target vegetation after application of chemical treatment.

Response: A detailed description of 2,4-D and its effect on the environment and application rates is discussed in Section 2.09 and in Appendix C.

5. Comment: According to the General Design Memorandum, the application rate will be four pounds of 2,4-D active acid equivalent per acre of vegetation. Is this an effective application rate in the proposed infested areas? Too little 2,4-D may stimulate vegetative growth (Final EIS, State of Washington, Aquatic Plant Management Program, October 1979). We have seen references where recommended application rates for 2,4-D were 20 pounds or more active acid equivalent per acre of vegetation in aquatic plant control programs.

Response: Extensive testing and field trials by the Corps of Engineers have shown the application rate of four pounds of 2,4-D active acid equivalent per acre of vegetation to be effective for controlling alligator weed and water primrose.

6. Comment: A description of 2,4-D's persistence in the water column following treatment should be provided as well as the following topics: its breakdown products, biological accumulation, acute and chronic toxicity, carcinogenicity, teratogenicity, and mutagenicity.

Response: See Appendix C.

7. Comment: We note that other aquatic vegetation species will be controlled with herbicides other than 2,4-D. The EIS should identify these herbicides and describe their effectiveness and potential environmental effects in the areas to be used.

Response: See Appendix C.

United States Department of the Interior

1. Comment: Page 4, Adverse Impacts

No mention is made that an eradicated nuisance plant could be replaced by an even more obnoxious species.

Response: This is a possibility but its probability does not appear sufficient to justify the toleration of existing aquatic plant problems, which in heavily infested areas may interfere with almost all uses of affected waters.

2. Comment: Page 8, Chemical Control

Experiments to develop selective control of aquatic vegetation for management should be addressed. The Elodea in Lake Marion could be managed to improve sport fishing opportunity. Strips of vegetation could be eliminated to provide boat access while retaining adjacent strips to harbor sport fish. The pattern selected should be aligned with the depths needed for boat access, standing timber, and other controlling physical conditions. A feasibility study should be undertaken by the Corps of Engineers and coordinated with the South Carolina Division of Wildlife and Freshwater Fisheries and the Fish and Wildlife Service.

Consideration should be given to measures for harvesting treated vegetation to minimize the buildup of decaying plant detritus.

Response: Selective vegetative management of elodea in Lake Marion would provide an attractive alternative from a sport fisherman's viewpoint. Unfortunately the bulk of nuisance aquatic plants in Lake Marion are located in waters inaccessible to mechanical harvesters and cutters. Shallow waters and stump and tree infested waters preclude the use of mechanical cutters and harvesters on a feasible basis. Furthermore, strip cutting of elodea, if practical, would be a continuous expensive operation. Elodea would be expected to continue to infest new waters at a rapid pace.

3. Comment: Page 12

We note some variation of your information to that of our records. We are enclosing our federally listed species for South Carolina and their general distribution as of August 1979. No critical habitat for any listed species has been designated in South Carolina.

Response: An updated list of species has been added to the final EIS.

4. Comment: Pages 12 and 13

The fact that the excess vegetation is non-native seems irrelevant as the basis for determining noxious vegetation. Removing it will not assure replacement with desirable vegetation but a likely replacement of vegetation causing the same problems. Any potential for establishing desirable waterfowl plants would be mainly fortuitous. Skills to manipulate a rooted aquatic vegetation is highly desirable, but has not yet developed as a dependable management technique in a large area.

Response: Wording in the final EIS has been changed from non-native species to noxious species. The opportunity for desirable waterfowl plants becoming re-established in noxious aquatic weed infested areas is greatly enhanced following a reduction of the more competitive species to be controlled under the proposed program.

5. Comment: Pages 12-15, Environmental Effects

This section fails to discuss the monitoring of water quality in conjunction with application of highly toxic herbicides such as ortho diquat. The decay of a large number of plants could result in oxygen depletion of significant magnitude to cause a fish kill. It would appear reasonable to enlist the aid of South Carolina Department of Health and Environmental Control to monitor water quality in all critical situations.

Response: Close coordination with the South Carolina Department of Health and Environment Control will be maintained during spraying operations. Appendix E contains EPA established tolerances for selected herbicides in potable water.

6. Comment: Page B-2

No herbicide is listed for control of Elodea. Yet large areas are reported to occur in Lake Marion (26,000 acres) and 240 miles of rivers and streams. Also, the General Design Memorandum No. 3 lists diquat, salts of endothall, copper compounds and other herbicides to be used for Elodea, etc., control. These aspects should be covered in the statement.

Response: The herbicides diquat, salts of endothall, and copper compounds are EPA registered aquatic herbicides which may be used on elodea in accordance with Section 2(7)(ee) of the Federal Pesticide Act of 1978. This information has been added to the final EIS.

United States Environmental Protection Agency

1. Comment: The DEIS states that the release of bound nutrients during decay of aquatic weeds may result in phytoplankton blooms. These blooms may stimulate zooplankton population growth and subsequently increase total fish production. However, the negative impacts of these blooms such as depletion of water column oxygen levels by algal decomposition, odor and taste problems, and reduction in aesthetic value were not discussed. Algal blooms may interfere with the intended uses of water in much the same way as the aquatic weeds themselves. A comparison of the positive and negative aspects of blooms would be valuable in determining cases where attempts should be made to foster this condition.

Response: The release of bound nutrients during decay of aquatic weeds may increase total phytoplankton biomass within the immediate area of treatment. However, the increase in phytoplankton is not likely to produce "blooms" of a problematic nature in streams or in the Santee-Cooper Lakes.

2. Comment: Mechanical methods of aquatic weed control were generally dismissed as "slow, expensive and inefficient." However, this technique can be an important adjunct to chemical aquatic weed control and should be included wherever feasible. It has the attendant benefit of removing weeds from a site where it has been determined that accumulation of nutrients in the water column or organic buildup in bottom sediment would be undesirable.

Response: Concur. A thorough study and discussion of mechanical control methods are included in the final EIS.

3. Comment: The DEIS acknowledges that the use of aquatic herbicides can cause unacceptable damage to beneficial, non-target vegetation. The destruction of such beneficial plants may indirectly impact aquatic life and waterfowl by reducing vegetation types which provide cover or grazing opportunities. This is even more likely if aerial application of herbicides is anticipated. Based on the Corps' experience in Florida and Alabama, the extent of the off-site, non-target damage should be discussed in the Final Statement.

Response: Although accidential drift of chemical herbicides is a possibility, application of herbicides will only be administered when weather conditions are suitable. Off-site, non-target damage is not considered to be a serious threat with proper application methods.

4. Comment: While we do not criticize the use of 2,4-D as the chemical of choice, there are other herbicides presently registered by EPA for aquatic control. Four of these, including 2,4-D, have received tolerances for use in potable water in the Eastern United States. (See attachment.)

Response: The herbicide 2,4-D is the most effective herbicide with EPA registration for use in controlling alligator weed and water primrose. Diquat would function as a contact killer only. Endothall and copper compounds are ineffective. See Appendix E for a listing of EPA tolerances for these pesticides in potable water.

5. Comment: Insufficient discussion is given to the possible health consequences both short and long term of higher levels of herbicides in potable water or food crops. Special precautions must be directed toward the use of chemicals around potable water supplies, especially near intakes. The maximum containment level (MCL) for 2,4-D in finished drinking water is 0.1 mg/L, so stringent measures may be necessary. We advise that the South Carolina Department of Health and Environmental Control (DHEC) and/or local water supply utility be contacted regarding this project for their expertise and assistance.

Response: We concur with your comment. See Appendices C and E for discussion of herbicides and related health effexts. The S.C. Department of Health and Environmental Control would be informed during herbicidal spraying operations.

6. Comment: The DEIS makes the general statement that since aquatic herbicides are generally absorbed by plants and mud, bioaccumulation has not proved to be a problem in their use. Nevertheless, the environmental mobility characteristics of the specific herbicide intended for use here, i.e., the amine salt of 2,4-D, should be given. The EIS should indicate whether this herbicide is readily absorbed/retained by aquatic weeds; will it be released in the water column upon plant decomposition, and is there a possibility of bioaccumulation or biomagnification effects with its use.

Response: See Appendix C for suggested information.

7. Comment: The DEIS contends that the use of aquatic herbicides, in general, results in little or no effect on phytoplankton, macroinvertebrate and crustacean communities. However, the Final Statement would be improved by specific details about the impact of these communities by the amine salt of 2,4-D.

Response: See Appendix C for suggested information.

8. Comment: The title of the document indicates this is a "cooperative" program. Yet the actual participants in the "cooperative" program other than Charleston District are not identified. The exact responsibilities of the Charleston District, as well as specific examples of coordination and cooperation with State and local authorities would be beneficial.

Response: The S.C. Water Resources Commission is designated as the State's lead agency for aquatic plant management. Responsibilities of the Corps of Engineers and Water Resources Commission is discussed in further detail in the General Design Memorandum No. 3, Aquatic Plant Control Program State of South Carolina.

## South Carolina Department of Health and Environmental Control

1. Comment: We are happy to see that mosquitos have been given some donsideration as an environmental impact.

We agree with the necessity to control aquatic weeds and feel that the EIS makes a fair presentation of the alternatives and their impacts.

Response: No response required.

## South Carolina Water Resources Commission

1. Comment: The South Carolina Water Resources Commission welcomes this aquatic plant management program and believes that the project will aid in managing an important water resource problem. This agency is intensely interested in the aquatic weed problem as it relates to surface water use. The proposed project is greatly needed and is consistent with this agency's plans and policies. We submit the following comments and suggestions in regard to this project.

The State should be included in the planning and management of the aquatic plant control program, as well as in field operations.

Response: The Corps of Engineers' Aquatic Plant Control Program is a cooperative program whereby the State of South Carolina, in particular the Water Resources Commission, will share responsibility in the planning and management of a control program for obnoxious aquatic plants in state waters.

2. Comment: An appropriate State agency should be designated to coordinate the involvement of other State agencies in this program and to represent all water use interests which may benefit from this project.

Response: It is the State's responsibility to determine which State agency should have the responsibility for coordination with the Corps. The State has delegated this responsibility to the S.C. Water Resources Commission.

Comment: This project is directly related to the interests and area of responsibility of the Water Resources Commission, which includes the protection and utilization of the State's surface water resources. This agency requests to be kept informed of activities conducted under this project and to be included in, at a minimum, the planning phase of the aquatic plant management program. We wish to have the opportunity to contribute to problem assessment, management strategy, and to establishment of control priorities.

Response: See response number 1.

4. Comment: There is some confusion concerning the areas of the State that will be eligible for aquatic plant control. In the Design Memorandum, page 3, part 6.1, it states -- "Project work may be performed in any river, lake, stream or waterway of the State..." -- and in the RDEIS, page 3, second paragraph, it states -- "Control operations would be confined to the area between the fall line and the upper limits of saltwater intrustion...". The status of the area northwest of the fall line should be clarified.

Response: The Aquatic Plant Control Program may include any river, lake, stream, or waterway of the State. Wording in the final EIS has been changed to include all State waters. It should be noted, however, that the bulk of obnoxious aquatic weed infestations occur in the area between the fall line and the upper limits of saltwater intrusion.

5. Comment: It is suggested that the project include a program of water quality monitoring, where chemical treatment is used, to document post-treatment levels of dissolved oxygen and other pertinent parameters.

Response: Close coordination with the South Carolina Department of Health and Environmental Control will be maintained during spraying operations.

6. Comment: There may be some circumstances under which mechanical control is desirable. Perhaps this control method should not be completely excluded from the project.

Response: Mechanical control alternative has been re-evaluated and included as a viable alternative in the final EIS.

7. Comment: We encourage the use of research funds to develop biological control methods for aquatic weed control. These funds should be made available to academic institutions in the State for biological control research.

Response: The Corps of Engineers' Waterways Experiment Station (WES) has been assigned the responsibility for the Corps' research on aquatic plants. WES accomplishes much of its research by contracts with educational institutions.

Office of the Governor, State of South Carolina

1. Comment: There are several points which we feel deserve mention. The first of these is that herbicides should not be used near sensitive habitats such as rookeries or spawning grounds, nor should they be used in areas where they may be washed into nontarget locations such as marshes.

Response: Herbicidal spraying within the District will be monitored and controlled to prevent drift to non-target areas. Care will be taken to avoid spraying near sensitive habitats.

2. Comment: Application of chemicals should be made in such a way that massive quantities of decaying plant material do not deprive fish of their oxygen supply.

Response: This would be done as stated in Section 4.01.7.

3. Comment: We would urge you to explore innovative alternatives to chemical control such as the use of biological agents where appropriate and the conversion of harvested aquatic weeds to ethanol.

Response: The Corps of Engineers' Waterways Experiment Station is administering an ambitious, on-going research program exploring biological control agents for controlling problematic aquatic plants throughout the United States. As bio-control agents are tested and proven effective they will be incorporated into the Corps Aquatic Plant Control Program.

4. Comment: Finally, we would like to see a portion of the aquatic plant control funds devoted to public education. In many cases, exotic aquatic plants become a problem when they are introduced to an area without natural controls. The public should be made aware of the problems associated with the introduction of exotic species.

Response: Funds for aquatic plant control are not sufficient for complete control of all aquatic plant problems, so specific funding for public education may not be available. Efforts would be made to keep the public informed about the on-going aquatic plant control program and advise of potential aquatic weed species.

South Carolina Department of Parks, Recreation and Tourism

1. Comment: The project seems to be consistent with the plans and policies of the Department of Parks, Recreation, and Tourism; however, I have some concern about the proposed chemical controls, especially the use of 2,4-D. To minimize the adverse impact of the use of 2,4-D, I would propose that the chemical be applied only during cooler weather.

Response: The South Carolina Water Resources Commission has recently been designated to serve as the State's lead agency for aquatic plant management.

In order to be effective, 2,4-D must be applied when plants are non-dormant and actively growing. In the case of alligator weed and water primrose, the active growing season occurs during the warmer months of spring and summer. Appendix C contains additional information about 2,4-D and its effect on the environment.

South Carolina Department of Archives and History

1. Comment: We note on page 4 that consideration has been given to cultural resources. Please note that there are many National Register properties in the lowlands and coastal areas as well as the uplands.

Since the project involves aquatic plant control activities restricted to the water zone, we concur with your opinion that no National Register properties or underwater cultural resources would be affected by control activities.

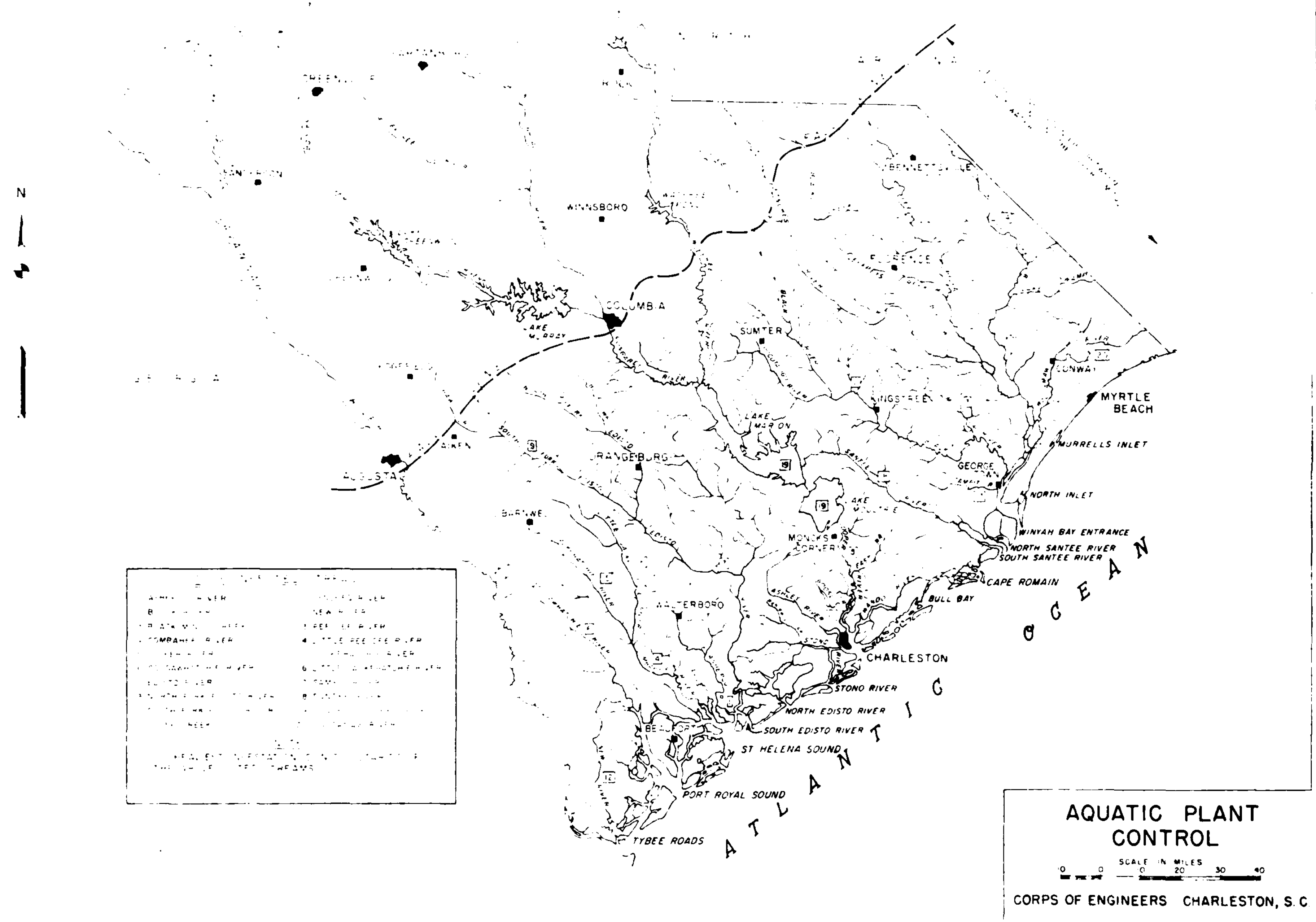
Response: No response required.

Institute of Archeology and Anthropology, University of South Carolina

1. Comment: This program affects water courses throughout the state. Although no immediate direct impacts may obtain for cultural or archeological resources (pg. 11), some of the long-term consequences of chemical or herbicidal additions to the water (pg. 8) and fluctuating water levels (pg. 8) may adversely affect site (and artifact) preservation.

Response: The Aquatic Plant Control Program should not affect cultural or archeological resources. Fluctuating water levels is not considered to be a feasible alternative. Additionally, the small quantity of herbicidal material added to the water would not effect cultural or archeological resources.

## INDEX, REFERENCES AND APPENDIXES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WALTERBORO
BEAUFORT
CHARLESTON
AIKEN
AUGUSTA
CONWAY
MYRTLE BEACH
MURRELLS INLET
NORTH INLET
WINYAH BAY ENTRANCE
NORTH SANTEE RIVER
SOUTH SANTEE RIVER
CAPE ROMAIN
BULL BAY
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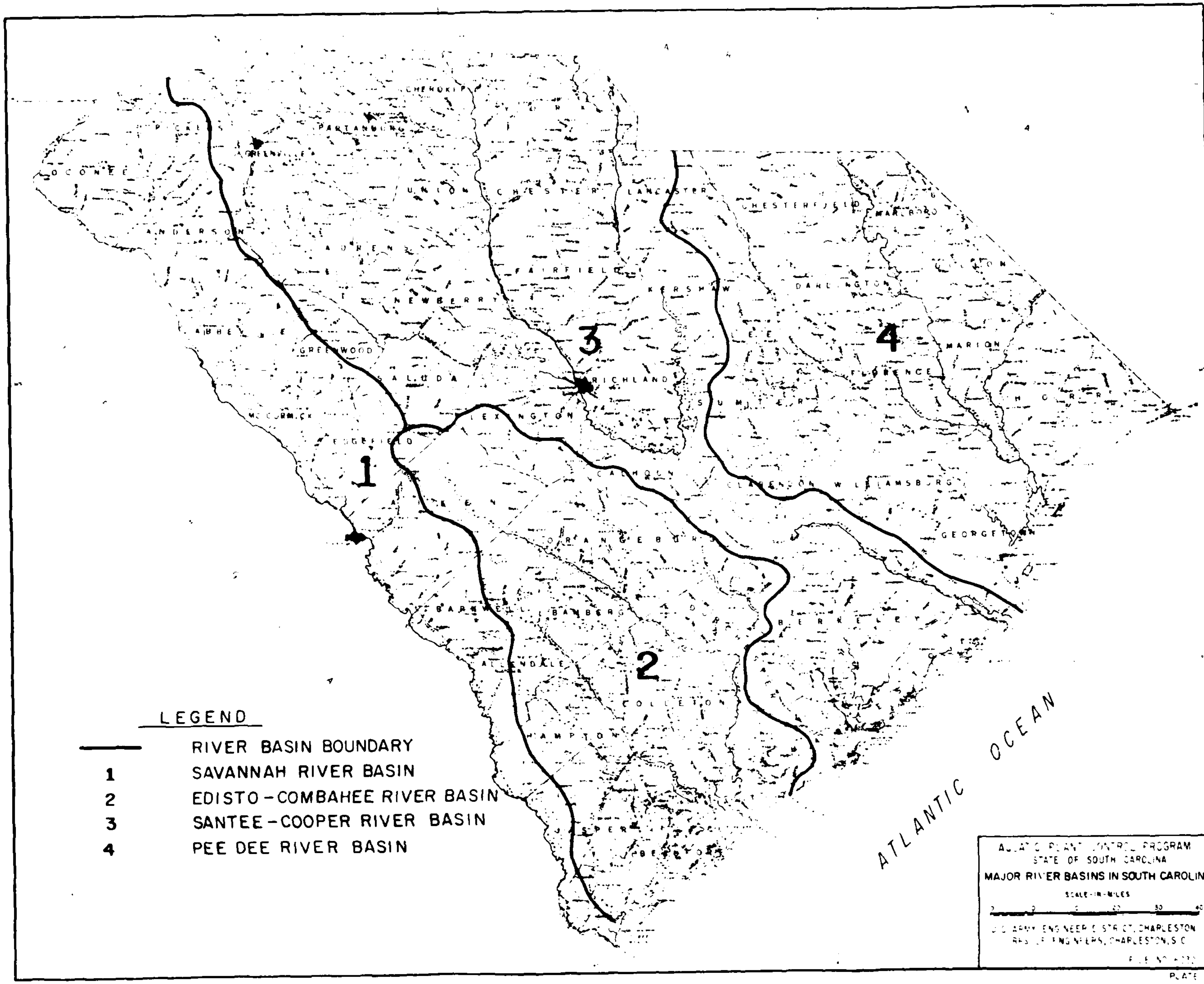
PLATE I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ATLANTIC OCEAN
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ANDERSON
GREENWOOD
SALUDA
NEWBERRY
FAIRFIELD
KERSHAW
RICHLAND
LEXINGTON
CALHOUN
ORANGEBURG
BARNWELL
ALLENDALE
COLLETON
HAMPTON
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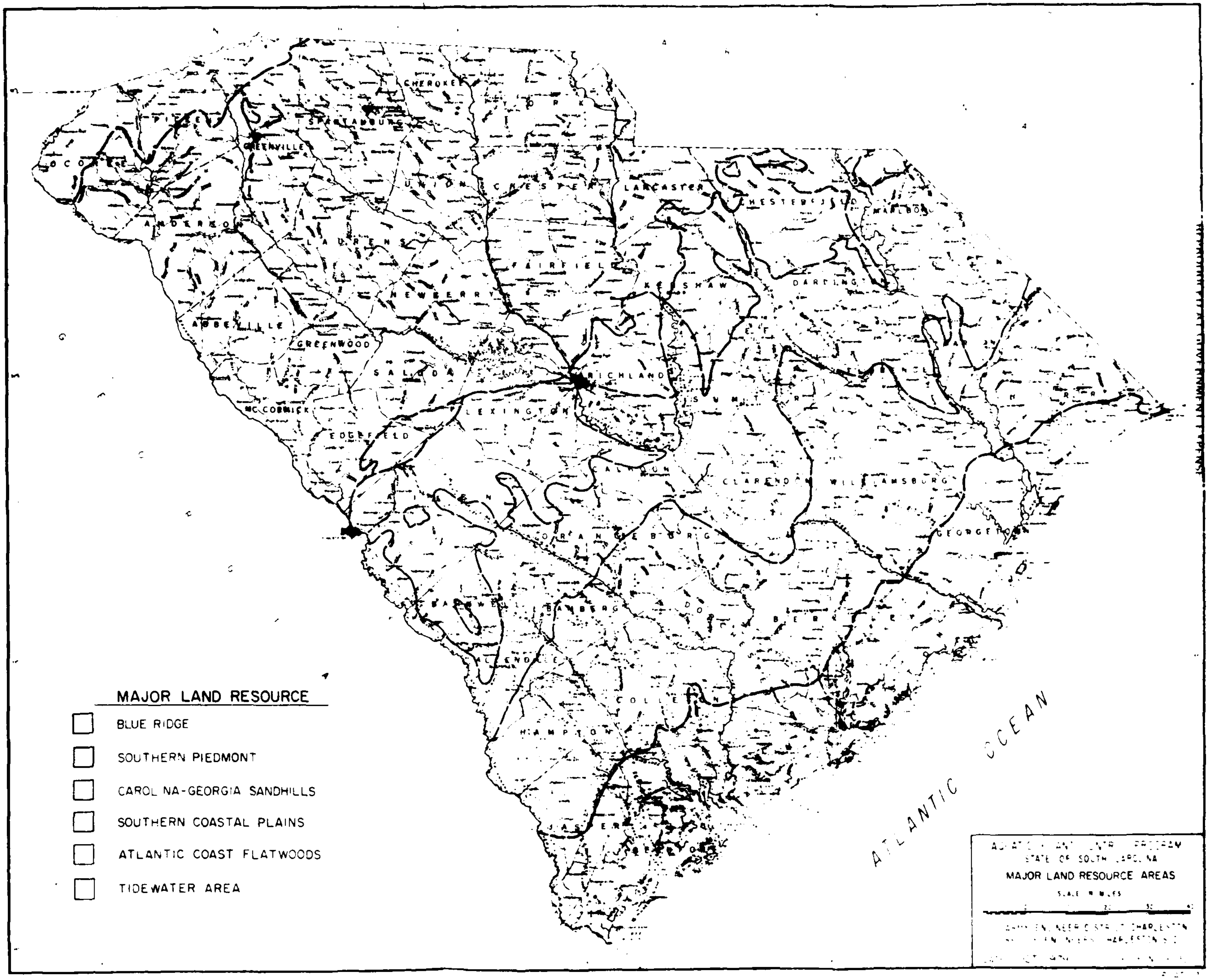
PLATE 2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CAROL NA-GEORGIA SANDHILLS
SOUTHERN COASTAL PLAINS
ATLANTIC COAST FLATWOODS
TIDEWATER AREA
ATLANTIC OCEAN
CHEROKEE
SPARTANBURG
GREENVILLE
UNION
CHESTER
LANCASTER
ANDERSON
LAURENS
FAIRFIELD
KERSHAW
DARLINGTON
NEWBERRY
ABBEVILLE
GREENWOOD
SALUDA
RICHLAND
LEXINGTON
EDGEFIELD
CLARENDON
WILLIAMSBURG
GEORGETOWN
ORANGEBURG
BAMBERG
COLLETON
HAMPTON
STATE OF SOUTH CAROLINA
MAJOR LAND RESOURCE AREAS

# appendix a

FISH AND WILDLIFE RESOURCES

The Charleston District, with a wide range of climate, aquatic environment and vegetative cover, supports a considerable variety of fauna. Over 400 species and subspecies of birds occupy habitats from the coastal wetlands to the upland forests of the Blue Ridge Mountains. Many of these birds are considered significant, especially waterfowl, birds of prey, and those species which are threatened or endangered, such as the red-cockaded woodpecker, Bachman's warbler, Southern bald eagle, Eastern brown pelican, and Peregrine falcon). Mammals are also widely distributed throughout the District, and a number of species are considered important. These include the larger game animals and aquatic fur bearers. Amphibians and reptiles such as salamanders, toads, frogs, snakes, turtles, and lizards are widespread and well diversified. Several species of sea turtles, the bog turtle, and the American alligator are endangered species. Fish are found all the way from the cold water mountain streams to the open water marine environment. Trout are important in the mountain streams, while various species of warm water fish are found in the streams, reservoirs and ponds at lower elevations. There are numerous species of saltwater fish and also several species of anadromous fish. Finally, the estuaries are fertile producers of shellfish, notably oysters, shrimp, and blue crab.

Although many environmental parameters influence the distribution of wildlife, vegetative cover is of particular importance. Therefore, the delineation of gross vegetative cover types will broadly define the major habitats found in the District. The distribution of plants can be related primarily to physical factors, such as topography, climate, and soils. However, human activities and developments have prevented normal vegetative growth and succession in much of the state. The remainder of this appendix relates in an overview fashion the important fish and wildlife species of the Charleston District to physiographic, vegetative and aquatic characteristics. Noteworthy sensitivities and vulnerabilities are described. Habitats can be classified into seven major types: (1) Upland Forests; (2) Interspersed Grasslands, Croplands, Woodlots, including Pine Plantations, and Orchards; (3) Coastal and Inland Marshes; (4) Riverine Wetlands; (5) Aquatic; (6) Beaches; and (7) Urban Areas.

## UPLAND FORESTS

This habitat consists of large, continuous, heavily wooded areas in the Blue Ridge Mountains; discontinuous blocks of hardwoods and pines in the southern and northern part of the Southern Piedmont; and scattered small forests within the Carolina-Georgia Sandhills, Southern Coastal Plain, and Atlantic Coastal Flatwood areas. There are two relatively large forested areas along the coast in Berkeley County, northeast of Charleston, and in Beaufort and Jasper Counties.

A white pine-hemlock forest type, in which eastern white pine or hemlock, singly or in combination, comprise a plurality of the stocking, occurs chiefly in the northern part of the Charleston District at the higher elevations of the Blue Ridge Mountains. The associates of this forest type are numerous, but none is particularly characteristic. The principal ones are beech, sugar maple, basswood, red maple, birch, black cherry, red and white oaks, yellow poplar, cucumbertree, and red spruce. In the development of vegetation toward the culminating stage in plant succession, white pine-hemlock, although near climax, would probably be succeeded eventually by northern hardwoods or hemlock. So long as the environment remains unchanged, however, this forest type will probably remain stable.

The [illegible] forest type consists of mixed hardwoods such as southern [illegible] oak, white oak, black oak, chestnut oak, hickory, and yellow [illegible] comprise at least 75 percent of the dominant and codominant [illegible] is found on mountain slopes, the rolling hills of the Piedmont, and occasionally on the drier sites of the Coastal Plain. The admixture of scrub oaks on drier, excessively drained sites of the Carolina-Georgia Sandhills includes such species as blackjack, bluejack, turkey and laurel oaks. In the Sandhills, there is a very characteristic assemblage of vegetation; namely, a longleaf pine-turkey oak-wire grass community on the ridges and pocosin or bog in the swales. The conversion of scrub oak and other low-quality hardwood stands to pine, a practice which became increasingly common during the 1960's, is changing the habitat characteristics of this area. The upland hardwoods in the Blue Ridge Land Resource Area are less sensitive than the scrub oaks which occur primarily in the Carolina-Georgia Sandhill Land Resource Area, and the few hardwood stands which grow on the drier sites in the Coastal Plain Areas. Water regime primarily governs the viability of these stands.

The oaks, which are represented mainly by the red oak group in terms of the number of different species present, are characteristically upland trees occurring on dry, sandy, or clayey soils. They are also found widely on loam soils and occasionally they occur along streams in fertile bottoms.

Hickories in the Charleston District occupy a diversity of sites from moist to dry ridges and hillsides with well-drained upland soils. Hickories tolerate a variety of edaphic and climatic conditions. They are climax species in the oak-hickory forest type throughout most of their range.

The upland hardwood forests of the oak-hickory type are excellent habitat for many wildlife species, particularly the gray squirrel, southern flying squirrel, ruffed grouse, wild turkey, black bear, and white-tailed deer. Mast from oaks, hickories, walnuts, and beech, and fruits of gum, wildgrape, dogwood, persimmon and other trees and shrubs provide ample food. Hardwood forests also provide tree dens for squirrels and raccoons and trunk dens for big animals, like the black bear. Extremely dense, mature hardwood stands are not particularly well suited to deer because the growth of understory vegetation, which provides browse, is restricted by overstory shading. Conversely, wild turkey find such conditions more favorable because of the abundance of mast.

A large percentage of the forests in the District consist of pines. They occur to a greater extent from the Piedmont to the Coastal Plain than in the Blue Ridge Mountains. Species found in the District include loblolly pine, longleaf pine, shortleaf pine, pond pine, and Virginia pine. These trees represent a natural successional stage in the reversion to the original hardwood forest types which have been cleared or otherwise altered. However, the majority of pine forest currently found in the Charleston District are the result of silvicultural practices rather than natural regeneration. Pines cannot withstand overstory competition and they require exposed mineral soils for effective regeneration. They are susceptible to a number of damaging insects and pathogens and are also susceptible to extensive changes in ground water level as well as prolonged surface flooding.

Virginia pine grows well in a wide variety of soils, but does best on clay, loam, or sandy loam. It will thrive only in moderately well-drained to well-drained soils, and is distinctly less tolerant of wet sites and impeded drainage than loblolly pine. Loblolly pine grows well on a wide variety of soils from the flat, poorly drained ground-water soils of the lower Coastal Plain to the old residual soils of the upper Piedmont. It grows best in soils with poor surface drainage. Loblolly pine may be found in mixture with shortleaf pine or in mixture with hardwoods. Shortleaf pine can grow on a great variety of soils, but the best sites are the fine sandy loams or loamy soils without a distinct profile, but with good drainage. Prolonged overstory competition is highly detrimental to reproduction. Longleaf pine grows best in soils characteristically low in organic matter, light-colored, sandy in the surface portion and medium to strongly acidic. Its distribution ranges from the coast up to the fall line, the southeastern boundary of the Southern Piedmont. Pond pine grows in the Coastal area, either alone or in association with loblolly pine and a number of riverine forest types. Although stands of pure pond pine most frequently occur on soils of high organic matter content, as in pocosins, the species develops best on mineral soils. The largest areas supporting only pond pine trees are found in poorly drained depressions (Carolina Bays) on the broad, interstream areas of the Coastal Plain. It should be noted, however, that these are not typical pure stands in that the trees are scattered and there is a dense undergrowth of evergreen scrubs, often ten to fifteen feet high.

By comparison with hardwood forests, mature pine stands furnish a smaller variety and quantity of food, and tree dens are less frequent and satisfactory. Animals of the coniferous forests are usually more food specific and also more tolerant of the dense cover conditions than are those animals associated with hardwood forests. When pines are managed as a forest crop, the harvesting cycle creates a varied habitat for wildlife. During the first few years of development, naturally regenerated or planted pine fields exhibit an open condition fostering an abundance of herbaceous browse. But as the pines mature, the stands become densely vegetated, shade out undergrowth, and thus support a lesser diversity of wildlife.

Individual coniferous trees serve as the den and food trees of certain fauna and are of particular significance with respect to the rare and endangered red-cockaded woodpecker. This bird makes its den in pine trees infected with red-heart disease.

While some mammals and resident birds may reside in only one of the forest types described above, others such as the white-tailed deer and rabbits may reside in more than one forest type.

Besides being important as a wildlife habitat, forested areas are significant in the preservation of high quality watersheds. The forest cover and litter lessen the impact of rainfall and allow for the slow percolation of water into the soil and groundwater reserves. If this cover is impaired, erosion problems can result, particularly in the steep topography of the Blue Ridge Mountains. When these already thin soils are further depleted by erosion, regeneration of natural forest cover is difficult to achieve. In addition, soil erosion leads to increased sediment loads in the streams with the attendant adverse impact on fresh water fish productivity.

## INTERSPERSED GRASSLANDS, CROPLANDS, WOODLOTS INCLUDING PINE PLANTATIONS, AND ORCHARDS

A mosaic of vegetative cover types were combined to form this habitat classification. Much of it consists of agricultural lands on which field crops such as soybeans, corn, small grains, cotton, tobacco, and truck crops are grown. A lesser category is the grasslands of improved and unimproved pasture and fallow fields which have converted to native vegetation. Discontinuous areas of mature forest land and pine plantations in varying stages of maturity are interspersed throughout this habitat. Most of the forested woodlots are pines.

As farmlands are abandoned and revert to natural vegetative cover, eventually to forest, wildlife species composition changes. Farmlands that once supported quail and rabbits have given way to forested land game species, particularly deer and turkey. In comparison to grassland and brush environments, cropland, because of modern clean farming practices, does not normally support as diverse a fauna. Nonetheless, it is not uncommon for grain fields and leafy crops to provide food for large numbers of migrating birds in the fall and spring, as well as for deer, wild turkey, dove, cottontail rabbit, quail, and other small animals. The bobwhite quail, mourning dove, and cottontail are the most important farm game wildlife resources in the District.

For some species, the proximity of the woodlot to nonforested or open areas is a basic requirement for their survival. In addition to the escape features of the wooded habitat, the open areas provide a source of food, particularly grasses and low herbaceous cover. Food for some wildlife is always available in the forest. It includes foliage from herbs, shrubs and juvenile deciduous trees; berries, nuts and other fruits; buds and bark; and insects attracted by sap. The activities of some wildlife can be damaging to forest vegetation.

On the pine plantations, short-term forest product management practices with harvesting usually in blocks and in regular cycles, provides cover in all stages of forest development, from newly planted clearings to mature trees. Though forested, these plantations take on the character of the interspersed cropland, grassland, and woodlot habitat and thus provide a "living space" for fauna requiring this type of environment.

## COASTAL AND INLAND MARSHES

This habitat consists of tidal salt water, tidal fresh water, and nontidal fresh water marshes. These wetland areas play a very important role in wildlife conservation, not only for waterfowl, but also for other species of wildlife.

Salt water marshes are an integral component of the estuarine intertidal and adjacent shallow-water zones. These zones are the most productive, and hence most important, parts of the estuarine nursery grounds. They are considered to be extremely critical habitats -- harboring, nourishing, and producing an exceptional variety of vertebrate and invertebrate fauna. While waterfowl are the most obvious occupants of this habitat, the young growth stages of many important commercial and sport fisheries species are dependent upon the nursery grounds for food and protection.

Salt water marshes can be classified as regularly flooded and irregularly flooded. The former type is found at intertidal elevations and may extend up the major rivers for some distance inland. Vegetation characteristically consists of almost pure stands of salt-marsh cordgrass. Open ponds in the marsh may support muskgrass, widgeongrass, or sago pondweed. Irregularly flooded salt-marsh is generally found along the coast between the salt-marsh cordgrass zone and the giant cutgrass zone of the major rivers. Vegetation is principally needlerush.

Tidal fresh water marshes have been divided into two types based on water depth: shallow and deep. The principal type of deep fresh water marsh in the coastal areas of South Carolina is the giant cutgrass marsh, which occurs along the larger streams that are subject to daily tidal effect. These marshes extend from the coast up the rivers, several miles in some instances. Most of these areas were used for rice farming in the 1800's and early part of this century, and while some of the old rice fields have grown up in cypress, most of those which are above the salt marsh are supporting giant cutgrass with a variety of other plants in the different soil and moisture situations. The shallow fresh water marshes are generally located along the larger streams in those portions subject to daily tidal effect. They are distinguishable from the deep fresh water marshes on the basis of shallower water and their vegetative composition (big cordgrass, maidencane, sedges, rushes, cattails, arrowheads, smartweeds, and pickerelweed).

These tidally affected, coastal wetlands and the associated bodies of open water are very important to numerous species of waterfowl. Of particular importance are the freshwater marshes, where most developments for the management of ducks are found. Undeveloped cutgrass marshes are used primarily during peak flights in the fall months. While the tidal rivers associated with the fresh water marshes provide little in the way of feeding areas for ducks, they do serve as concentration areas, attracting and holding large numbers of ducks which utilize adjacent ponds and waterfowl development areas for feeding. They are also utilized as resting areas for migratory waterfowl, particularly during peak migration periods in the fall. While the dense salt marshes are too thick to be utilized by ducks, the tidal guts, ponds, and edges of the marshes do receive some use. Over 200,000 puddle ducks and a significant number of diving ducks, rails, and coots winter in the coastal areas. Other important waterfowl that winter here, but in far fewer numbers, are Canada geese (less than 10,000), snow and blue geese (about 300), and whistling swans (about 100).

Besides waterfowl, the coastal marshes harbor a number of other significant wildlife species, including the bald eagle and alligator. The marshes are also essential habitat for shrimp, oysters and crabs, and many species of fin fish.

The non-tidal fresh water marshes in the Charleston District are very limited. The shallower marshes occur principally in Lake Marion and Lake Moultrie, to some extent in practically all of the numerous lakes and ponds throughout the Southern Coastal Plain and Atlantic Coastal Flatwoods, and in restricted areas along streams. The vegetation is generallly composed of maidencane, cattails, smartweed, rush, spikerush, and various species of

...dge... ...ep ...shes occur along the shoreline in many ponds and to a ...ted extent in the reservoirs. Principal plant species are cattails, ...dden... ...e ...nd bulrushes, with white and yellow waterlilies, pondweeds, wa...ershield, and other aquatic species.

Compared to the coastal marshes, these fresh water inland marshes are ...nerally less important to waterfowl. However, the marshes and open water ...re... Lake Marion and Lake Moultrie are significant wintering areas for waterfowl using the Atlantic flyway.

The wetlands are particularly sensitive to changes in the depth and frequency of flooding, to pollution by industrial and municipal wastes, and to siltation. The tidal marshes are also acclimated to prevailing water salinity, and therefore sensitive to changes in the fresh water flow that would cause relocation of the normal salt-brackish-fresh water boundaries. Losses of wetlands to date have resulted principally from agricultural drainage enterprises, flood control activities, and fill for residential, business, and residential developments. Construction of canals and connecting waterways has allowed salt water penetration into fresh water lagoons and marshes; it has also produced abnormally low water tables at low tide, which is damaging during a drought. Ditching for mosquito control and saltmarsh hay production has tended to reduce open water areas, thereby reducing the invertebrate population essential to waterfowl, shorebirds, and fish. Road construction has induced drainage and filling operations as well as expanded development in the general area.

RIVERINE WETLANDS

This forested habitat is distinguished from the upland forests discussed earlier in that it covers wooded and shrub swamps and seasonally flooded bottomlands.

Shrub swamps are limited to very small areas along streams and in the heads of embayments or impoundments. They generally consist of willow and alder. On the other hand, wooded swamps are quite extensive and are located throughout much of the District. They occur extensively along coastal plain streams, in the Carolina Bays, and in numerous small swamps throughout the Atlantic Coastal Flatwoods area. Above the fall line, however, they occur only in narrow bands along streams.

A layer of water as much as one foot deep often covers the surface area of these swamps. Water tolerant bald cypress and tupelo gum occupy these perpetually swampy sloughs and low-lying areas, while bottomland hardwood species occupy the drier sites. Sections of Four Holes, Congaree, and Santee Swamps are excellent representations of stands of bald cypress and tupelo gum. More than 90 percent of the natural bald cypress stands are found on flat or nearly flat topography at elevations of less than 100 feet above sea level. Bald cypress is intermediate in its tolerance to shade. Stands of these trees become stagnated because individual trees do not express dominance as crown canopies close. On less moist sites on slightly elevated ground, bald cypress may be associated with sweet gum, oak, pond pine, and loblolly pine. Tupelo gum

regeneration requires open, very wet, poorly drained soils. The tree is intolerant of shade, and requires full light for satisfactory germination and seedling development. Hence, its occurrence tends to be restricted to drowned sites such as beaver ponds, where other trees cannot survive. Any major change in the normal water level sharply decreases growth and may cause mortality of the trees and loss of this wildlife habitat.

There is considerable acreage of wooded swamps in the Carolina Bays in the middle and upper Coastal Plain. This gently rolling area consists of numerous soil depressions and hummocks. Many of these depressions have an impervious subsoil which traps runoff and thus they may contain water or water-logged soil for extended periods. The vegetation is variable due to the varying degree of wetness found among the bays. The drier bays support oak species, black and sweet gum, loblolly pine, hickory, and a variety of shrub species in the understory. Some of these bays contain standing water throughout the year. Typically, they contain standing water for varying periods almost every year and contain cypress, black gum, and sweet gum with oaks and loblolly pine in the drier portions.

The seasonally flooded bottomlands are found in those stream bottoms which are fairly well-drained during most of the year. The bottomland hardwood forests are composed principally of black gum, sweet gum, tupelo gum, overcup oak, water oak, red maple, and ash. These overflow areas are located principally below the fall line in the better drained sections of the river bottoms and along tributary streams. They are present to a limited degree along most of the rivers throughout the Piedmont. In the flat topography of the Coastal Plain and Atlantic Coastal Flatwoods, where there is frequent flooding in most stream bottoms, the typical bottomland hardwoods are limited to ridges and edges of the bottoms.

The riverine wetlands are a great reservoir of wildlife. Their situation, vegetation, and abundant natural food produce conditions ideally suited to the needs of a variety of species. Significant examples of this habitat are the Santee Swamp, Four Holes Swamp, and the Congaree Swamp. Although fauna of all types are well represented, bottomland areas are generally low in waterfowl value because of insufficient permanent water areas. They do not provide wet habitat consistently enough to winter large numbers of migratory birds, but the resident wood duck is widespread in the environment. The value of this habitat for other avian populations is great. Songbirds are many, owls and hawks numerous, and coot, jacksnipe and woodcock are common, along with the wild turkey. During the fall, swamp tupelo provides food for large numbers of such migrating birds as robins, bluebirds, blackbirds, and cedar waxwings. Additionally, the Southern bald eagle may be seen here. Bachman's warbler, a rare songbird, has been sighted in this type of habitat.

Small game animals and fur animals are in general abundance, being represented by marsh rabbits, squirrels, opossums, raccoons, foxes, muskrats, minks, and otters. Beaver colonies are established in the upper and lower Savannah and Santee Rivers, in the Waccamaw River drainage near Myrtle Beach, and occasionally in other heavily timbered swamplands. As an endangered species, alligators are an important inhabitant of the riverine ecosystem.

The forest canopy provides shade which affects water temperature of the aquatic habitat. The insects that fall into the water from overhanging vegetation provide food for fish. Additionally, the roots of the trees and shrubs on stream banks bind the soils, hold the banks in place, and afford retreats for fish.

AQUATIC

This habitat consists of marine and fresh water sources. The marine habitat is large, abundant and varied, including networks of saltmarsh creeks which are common in the coastal wetland habitat, numerous ocean inlets, large sounds, brackish water rivers and an extensive offshore area. Approximately 160 species of fish are found in the salt waters of the Charleston District. The major ecological groupings are inshore species, both resident and migratory, found commonly close to shore and in coastal estuaries (such as black drum, flounder, sheepshead, shad, and striped bass), offshore migratory species (such as tunas, mackerels, jacks, bluefish), and offshore bottom fish (such as black sea bass, snappers, porgies, and grunts). The most important group are the inshore species because of their greater availability to fishermen. The Atlantic and shortnosed sturgeon are anadromous fish occurring in most of the District's coastal waters.

Oysters, shrimp and blue crabs are the commercial shellfish species of importance in the District and the estuarine zone provides the environment in which these aquatic life multiply. Shrimping grounds occupy approximately 27,000 acres offshore.

Fish and shellfish are not the only inhabitants of the estuarine zone. Surface users include a host of significant shorebirds, including the American oystercatcher, a bird that relies chiefly on mollusks for its food source. The endangered Eastern brown pelican is relatively abundant in coastal South Carolina.

Fresh water fish habitats range from the cold water streams of the mountains in the northwest corner of the District to the warm water rivers, ponds, and reservoirs found at the lower elevations. Although some streams are stocked annually, others support natural reproduction of brook, rainbow and brown trout. The distribution of these waters is limited to elevations mainly above 1,400 feet above sea level where water temperature is sufficiently low to support these species. Additionally, at lesser elevations, there is a two-story fishery in Jocassee, Hartwell, and Clark Hill reservoirs and the tailrace canals of the latter two lakes, as well as the Saluda River below Lake Murray Dam. Warm water fish occur throughout miles of rivers and thousands of farm ponds, and natural and man-made lakes. The 76,400 acres of farm ponds in South Carolina receive a large share of the total fish hatchery production. Smallmouth bass range to lower reaches of trout streams as does the Coosae or "redeye" bass. These species prefer the cooler swift mountain streams which are too cold for most other warm water species, yet too warm for trout.

Unique to the Charleston District are the lakes of the Santee-Cooper Reservoir where a self-sustaining population of landlocked striped bass (rockfish) exists. The striped bass stocking programs in the other state reservoirs are dependent upon brood fish taken from the Santee and/or Cooper Rivers. Also dependent upon these rivers is the striped bass/white bass hybrid which is stocked in Hartwell and Clark Hill reservoirs.

Some of the better river habitats for fresh water game fish are the Edisto, Little Pee Dee, and Coosawhatchie Rivers, because they are "blackwater" streams coursing through the swamps of the lowcountry. Most coastal streams serve as nursery areas for anadromous species such as American shad, hickory shad, blueback herring, white perch, striped bass, the Atlantic sturgeon, and the shortnosed sturgeon.

## BEACH

The beach habitat is the least extensive in area within the District. Beaches northeast of North Inlet have become primarily a recreation area. The beaches extending from North Inlet southwestward along the coast are biologically important to the survival of a number of endangered and significant species. The loggerhead turtle annually returns to some of these beaches to lay its eggs in the sand before returning to the ocean. The beach area in the Cape Romain National Wildlife Refuge is heavily used by sea turtles. Additionally, various species of shorebirds nest along or immediately behind the beach.

## URBAN AREAS

Urban and suburban environments, with their parks and other vegetated open areas, also provide a habitat for various animals. Birds and small animals that are adaptable enough to live in the shrubs and lawns around human habitation occupy a significant segment of this environment. In many cases, birds such as robins, cardinals, mockingbirds, and various other songbirds have become more numerous in recent years because of the increased interest of people in maintaining feeding stations, nesting boxes and other bird attractants.

# appendix b

NOXIOUS AQUATIC PLANT
RECONNAISSANCE SURVEY
STATE OF SOUTH CAROLINA

INTRODUCTION: Plants form one of the most conspicuous parts of a lake or stream environment. Their role is highly important, for only plant life can convert solar energy into the chemical energy in stored food. Many aquatic plants are desirable to the fish and other fauna of the aquatic environment and are an essential part of a well-balanced system.

However, proper management of aquatic plants in an aquatic system is often complicated by the introduction of exotic (non-native) plants into the system. Many of the most noxious aquatics are exotic plants that have escaped into the waters of South Carolina. Their competitiveness and overabundant growth, in many instances, makes them undesirable. Excessive growths of noxious aquatic plants interfere with man's navigation and other water-related activities. Native plants may become a problem in highly eutrophic water or where the water has special usages (irrigation, recreation, navigation, etc.).

In order to provide proper management and control, a reliable estimate of the species and quantity of noxious aquatic plants is necessary. The scope of the noxious aquatic weed problem in South Carolina was determined through field reconnaissance surveys.

Survey

Survey Technique. The bulk of noxious aquatic infestations occur between the fall line and the coastal salt water intrusion zone in South Carolina. Therefore, the present survey was conducted in the Coastal Plain region and was carried out during the summer of 1979. The survey was accomplished by boat and supplemented by observations at bridges where bridge crossings were located between selected boat launching ramps. Particular attention was devoted to those water bodies where responses to our inquiries indicated that aquatic plants grew profusely. Survey efforts were also intensified on those water bodies on which enough aquatic plant growth was observed during the initial inspection to indicate there was potential for problem growths in other areas of that water body. When aquatic growths were found, notes were made on the species composition and percentage of water area infested with each plant species.

Survey Results. Three species of exotic, aquatic plants were found to be causing problems in various water bodies throughout the Coastal Plain region. The three plants included: Brazilian elodea (*Egeria densa*), alligator weed (*Alternanthera philoxeroides*), and water primrose (*Ludwigia uruguayensis*).

Plates 1-3 show the streams, rivers and lakes which are infested with the aforementioned plants.

Alligator weed: Although alligator weed is widely spread throughout the eastern part of South Carolina, it was not impeding navigation in any major waterways. Rank growths of alligator weed, however, were obstructing many slow-moving back waters, coves and ox-bows. Biological control agents, primarily stem borers, were providing excellent late summer and early fall control of the plant. Swamp smartweed (*Polygonum densiflorum*) developed vigorous growths on the alligator weed mats as alligator weed was suppressed during late summer. Approximately 900 acres of alligator weed infested waters occur in state waters.

Elodea: This submersed aquatic has rapidly extended its range throughout the Coastal Plains of South Carolina. Two waterways, North Fork Edisto and Lake Marion, are infested to the extent of impeding navigational traffic.

Approximately 26,000 acres of upper Lake Marion and 240 miles of rivers and streams (approximately 4,000 acres) are infested with Elodea. The probability of this aquatic plant rapidly infesting other water bodies in the state appears high.

Water Primrose: An emersed, floating plant, water primrose is rapidly becoming a nuisance plant in several waterways. Its growth habits resemble those of alligator weed. It is capable of completely blocking a channel. In Lake Marion it usually grows as a surface mat over Egeria. In other areas, such as the Cooper River and Horseshoe Creek, water primrose grows as a surface mat without the support of Egeria. Water primrose has the potential of becoming a serious noxious weed in South Carolina. It appears more cold-hardy than the other two exotic species, as evidenced by the fact that it is established in Lake Hartwell near Clemson, and several small lakes in Spartanburg County. Approximately 6,000 acres of Lake Marion and 120 miles of rivers and streams (approximately 3,000 acres) are infested with water primrose.

Potential Problem Plants

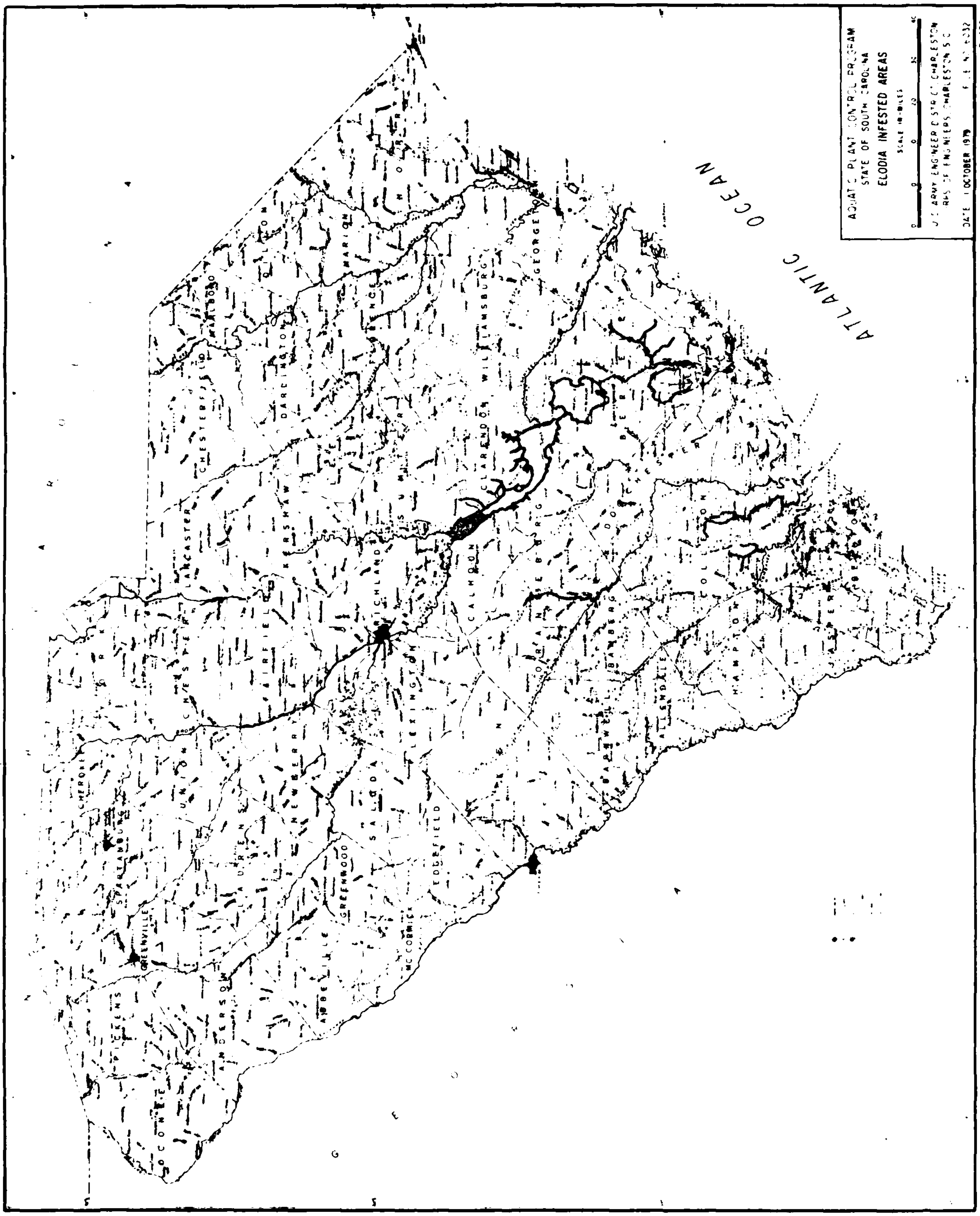
The following aquatic plants are present in many of the rivers and lakes in the state. They are not causing serious navigational problems, but appear to have the potential for becoming a serious problem.

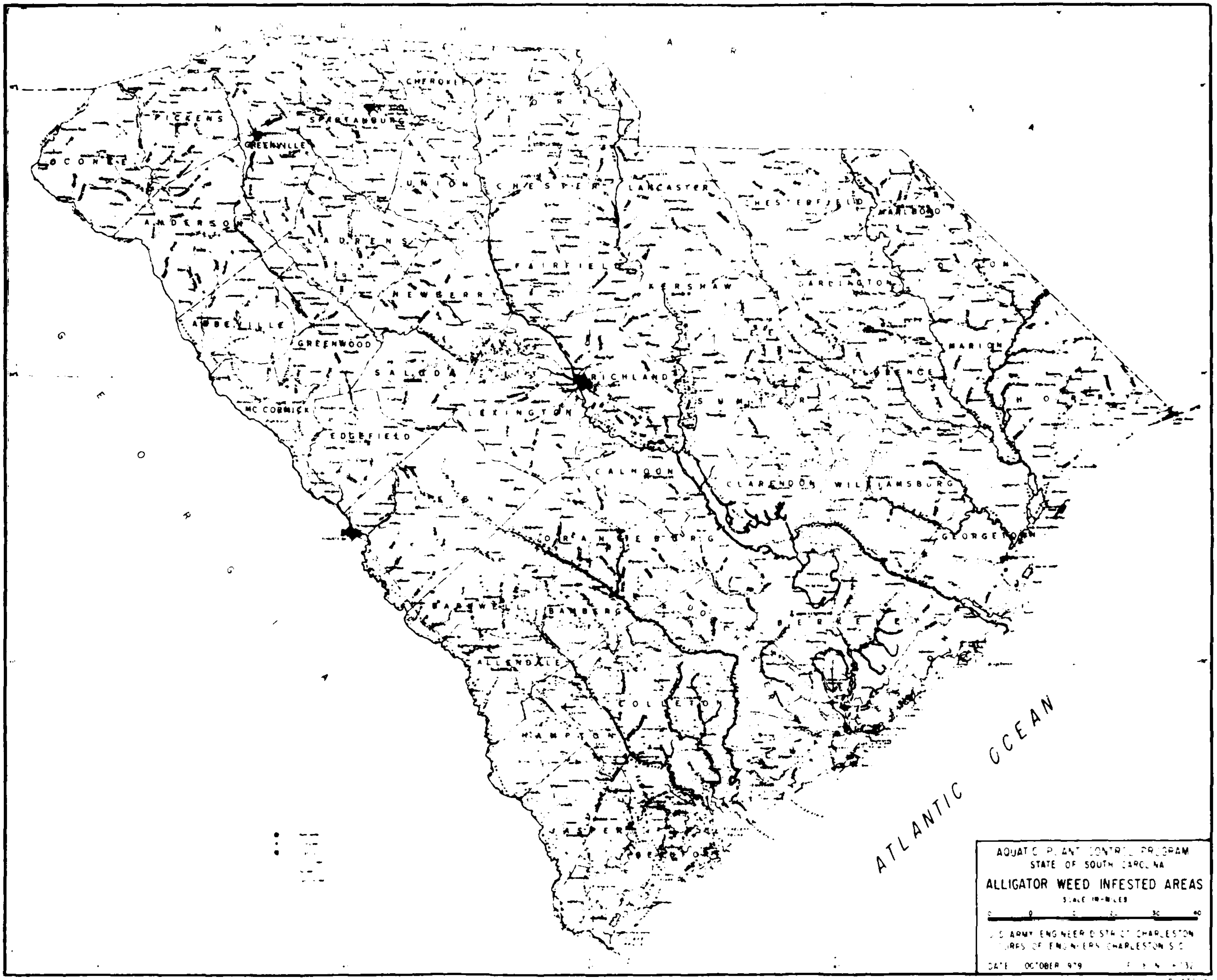
| Common Name | Scientific Name |
|---|---|
| Spiney naiad | *Najas minor* |
| Southern naiad | *Najas guadalupensis* |
| Coontail | *Ceratophyllum demersum* |
| Fanwort | *Cabomba caroliniana* |
| Bladderwort | *Utricularia spp.* |
| Smartweed | *Polygonum densiflorum* |
| Common reed | *Phragmites communis* |

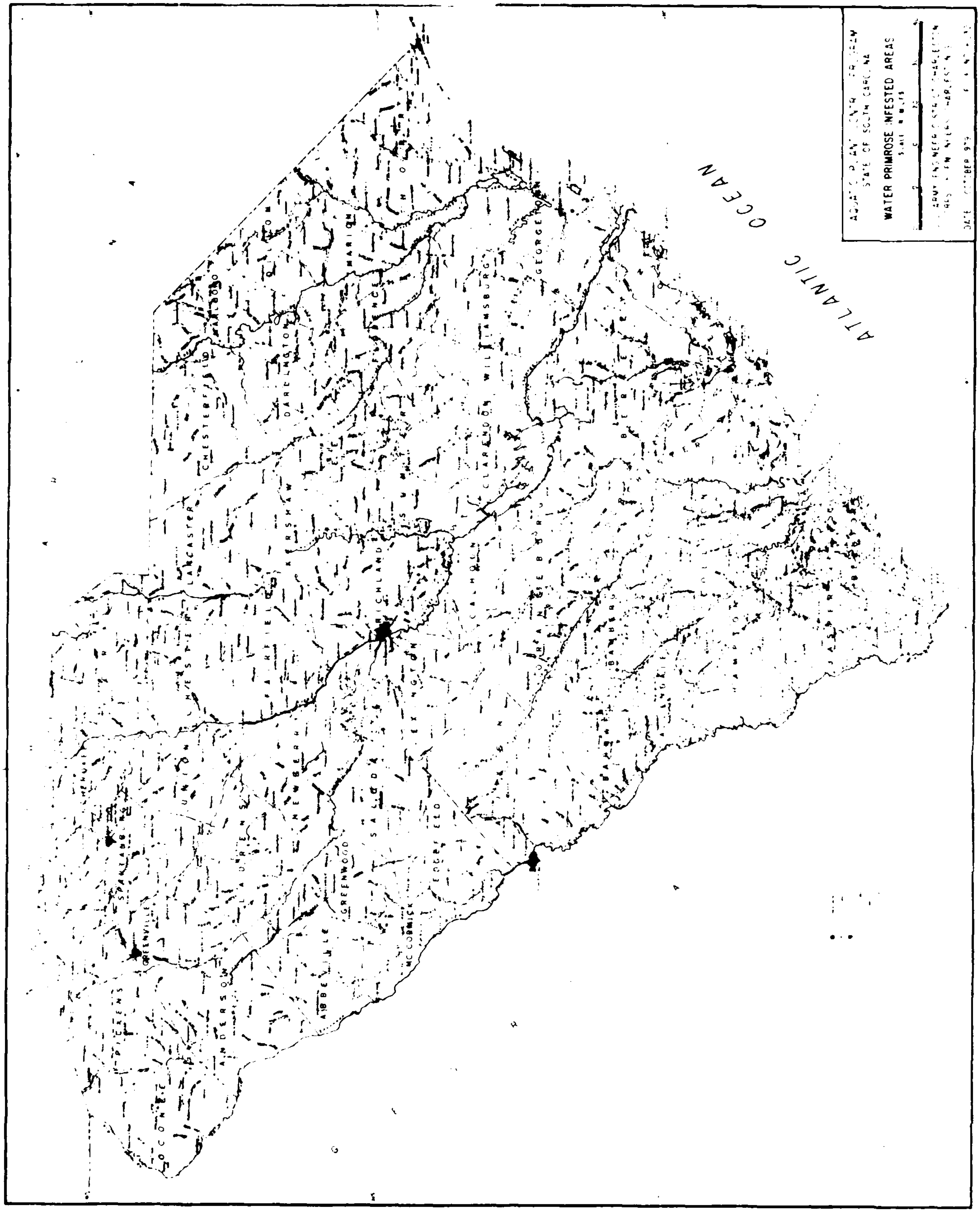
The following aquatic plants are not established in the state, but are considered as potentially a problem due to the probability of their introduction and suitability of environmental conditions for their growth and proliferation.

| Common Name | Scientific Name |
|---|---|
| Hydrilla | *Hydrilla verticillata* |
| Eurasian water milfoil | *Myriophyllum spicatum* |

Conclusion. Brazilian elodea and water primrose are two aquatic plants which are currently restricting the use of certain public waters in South Carolina. They are a major problem in Lake Marion and in portions of the


AQUATIC PLANT CONTROL PROGRAM
STATE OF SOUTH CAROLINA
ELODIA INFESTED AREAS
SCALE IN MILES
0 10 0 20 30 40
DATE 1 OCTOBER 1979
ATLANTIC OCEAN
OCONEE
PICKENS
ANDERSON
GREENVILLE
SPARTANBURG
CHEROKEE
UNION
LAURENS
ABBEVILLE
GREENWOOD
McCORMICK
EDGEFIELD
SALUDA
NEWBERRY
LEXINGTON
RICHLAND
FAIRFIELD
CHESTER
LANCASTER
KERSHAW
CHESTERFIELD
MARLBORO
DARLINGTON
FLORENCE
MARION
DILLON
HORRY
GEORGETOWN
WILLIAMSBURG
CLARENDON
SUMTER
CALHOUN
ORANGEBURG
DORCHESTER
BERKELEY
COLLETON
BAMBERG
BARNWELL
ALLENDALE
HAMPTON
JASPER
BEAUFORT


AQUATIC PLANT CONTROL PROGRAM
STATE OF SOUTH CAROLINA
ALLIGATOR WEED INFESTED AREAS
SCALE IN MILES
DATE OCTOBER 1979
ATLANTIC OCEAN
PICKENS
OCONEE
GREENVILLE
SPARTANBURG
CHEROKEE
ANDERSON
LAURENS
UNION
CHESTER
LANCASTER
CHESTERFIELD
MARLBORO
FAIRFIELD
KERSHAW
DARLINGTON
NEWBERRY
ABBEVILLE
GREENWOOD
SALUDA
RICHLAND
MARION
FLORENCE
HORRY
MC CORMICK
LEXINGTON
SUMTER
EDGEFIELD
CALHOUN
CLARENDON
WILLIAMSBURG
ORANGEBURG
GEORGETOWN
BARNWELL
BAMBERG
BERKELEY
ALLENDALE
COLLETON
HAMPTON
JASPER



STATE OF SOUTH CAROLINA
WATER PRIMROSE INFESTED AREAS
ATLANTIC OCEAN
MARION
DARLINGTON
LANCASTER
KERSHAW
CLARENDON
CALHOUN
GREENWOOD
GREENVILLE
PICKENS
ANDERSON
MC CORMICK

# appendix c

HERBICIDES PROPOSED
FOR USE IN THE
AQUATIC PLANT CONTROL PROGRAM

## APPENDIX C

### HERBICIDES USED IN AQUATIC PLANT CONTROL ACTIVITIES

The herbicides proposed for use in aquatic plant control activities in the Charleston District include 2,4-dichlorophenoxyacetic acid (2,4-D), diquat, copper complexes, and endothall. Two formulations of 2,4-D could be used: dimethylamine salt (DMA) and butoxyethanol ester (BEE).

### 2,4 DICHLOROPHENOXYACETIC ACID

The chemical compound 2,4-dichlorophenoxyacetic acid, commonly called 2,4-D is a phenox herbicide widely used for the selective control of broadleaf weeds in lawns, pastures, ceral crops, and aquatic plants. It is also used in small concentrations to control fruit-drop in some fruiting trees (Thompson, 1970).

The compound was developed during the early 1940's as a plant growth regulator. The herbicide qualities were soon discovered and research into its possibilities as a weed killer was begun.

The original research and development of 2,4-D as a herbicide utilized the free acid. In this form it is a white cyrstalline substance that is relatively insoluable in water. Because of this quality and other difficulties such as a low level of herbicidal activity, other formulations were developed. Generally these fall into three basic categories. They are salts, high-volatile esters and low-volatile esters. Each of these groups exhibits characteristic physical and herbicidal properties and each group, in turn, contains a number of formulations varying in physical, and herbicidal properties.

The high-volatile esters such as the methyl, ethyl, butyl and isopropyl esters are generally the most active formulations and exhibit the lowest selectivity in the scope of plants affected. They are more toxic to animals than the other formulations and have a tendency to volatilize and be carried by air currents for great distances (Thompson, 1970).

The low-volatile esters, such as butoxyethanol, propylene glycol, and propylene glycol butyl ether esters, are generally less active, less toxic, more selective, and are not as easily volatilized as the high-volatile esters.

The salts such as dimethylamine, triethylamine, alkanolamine, sodium and ammonium salts are generally the least active, least toxic, most selective, and least volatile of the 2,4-D formulations.

The formulations which would be used by the Corps of Engineers for alligator weed and water primrose control are the dimethylamine salt (DMA) and butoxyethanal ester (BEE) formulations.

The dimethylamine (DMA) salt formulation of 2,4-dichlorophenoxyacetic acid has a molecular formula of $C_{10}H_{13}C_{12}NO_3$, a molecular weight of 266.1 and in the pure form is an odorless white crystal. It melts between 185 degrees and 188.6 degrees F. and decomposes at its melting point. It is extremely soluble in water (1 pound of water will hold 3 pounds of 2,4-D DMA in solution) and is also soluble in methyl, ethyl and isopropyl alcohols and acetone. It is insoluble in kerosene or diesel oil (Thompson, 1970).

The assessment of the total effects a pesticide may have on the environment and its ecological implications must take into consideration various properties of the chemical in question. These can be generally summarized as follows:

1. Toxicity to plants and animals.
2. Persistence of the pesticide in the environment.
3. Movement of the pesticide within the environment.
4. The rate and interval of pesticide application.

The following discussion of 2,4-D, will explain the DMA, and BEE formulations as well as other formulations of the chemical. The data compiled for the other formulations cannot be directly used in a discussion of the DMA, and BEE formulations but serve to augment the material presented for these formulations.

Toxicity. For comparative purposes, the toxicity of a pesticide is usually presented as the acute toxicity. The acute toxicity of a chemical is the amount necessary to kill half a population of test animals. For oral or intravenous administration it is expressed in milligrams of chemicals per kilogram of body weight. This is called the $LD_{50}$ or lethal dose to 50% of the test animals. For the acute toxicity of water concentrations of chemical to aquatic animals it is called the $LC_{50}$, or lethal concentration to 50% of the test animals. This is expressed as mg of chemical per liter of water.

The acute toxicity also gives an indication of the possible direct toxic effects to animals to be expected from a pesticide application. Table C-1 gives the toxicity of 2,4-D to various aquatic and terrestrial animals and plants. Also presented, for comparative purposes, is the toxicity for some of the commonly used insecticides, aspirin, and table salt.

Toxicity of 2,4-D to man is not considered to be great. Two suicides, where large quantities were taken orally, are the only documented cases of fatal poisoning (see Table C-1). Illness has followed the spilling of the concentrated ester formulations on the skin where it was not washed off. The reported cases were for 4 patients, aged 39, 50, 52, and 65 (Berkley, et. al., 1963; Goldstein, et. al., 1959). Berkley, et. al., concluded that due to the widespread use of 2,4-D and the rarity of resultant neuropathy, a person affected by the chemical probably has a predisposition to this disease or is sensitive to the chemical (Berkley, et. al., 1963). Some formulations may contain petroleum distillates, which in themselves may cause discomfort (Anonymous, 1972). There have been some cases of various ailments reported

from plants where 2,4-D and 2,4,5-T were manufactured. The lack of such ailments in individuals applying 2,4-D over many years, however, indicates that exposure to raw chemicals or possibly TCDD from the 2,4,5-T were the probably causes of this condition. One man has been reported to have ingested 500 mg of purified, 2,4-D for a period of 21 days without ill effects (Seabury, 1967). At the concentration used for alligator weed and water primrose control, approximately 1/2% 2,4-D DMA solution by volume, it is highly unlikely that man could receive a toxic dose from the spray application. Safe handling and storage of the concentrate precludes the possibility of accidental poisoning by this route.

The plant toxicity of a herbicide for plant control measures should be evaluated for a determination of its possible effects to other plant species. The compound 2,4-D as previously mentioned has been used extensively for the elimination of broadleaf weeds in lawns and cereal crops. The chemical's quality of affecting broadleaf plants at relatively low applications rates without damage to narrow leaf plants has made it useful as a selective herbicide. In the application of 2,4-D to alligator weed and water primrose, concern for nontarget plants is mostly confined to bordering terrestrial broadleaf plants which may be affected by spray drift. Proper application techniques reduce this possibility substantially.

Most other aquatic plants are protected by the diluting effect of the surrounding water. Few indigenous aquatic plant species are floating, the majority are either submersed or emergent. The submersed species, including algae, have been shown to be resistant to concentrations of 2,4-D likely to develop in the water after alligator weed and water primrose treatment (Lawrence, undated; Lawrence, 1960). The adherence and absorption of the chemical to alligator weed and primrose plants prevents an excess of the spray solution from reaching the water. The spray solution that does come in contact with the water from overspray and runoff is quickly diluted to concentrations which are unharmful to the submersed species.

Emergent species may be destroyed when mixed with heavy growths of alligator weed and primrose as they may receive treatment along with the target species. Many of the emergent broadleaf plants such as spatterdock, Nuphar advena and pickerelweed, Pontederia lanceolata experience defoliation at the rates applied to alligator weed and primrose but regrow from the rhizomes. Emergent and bank grasses, which are widespread in the Charleston District are resistant to 2,4-D at the rates applied to the target species.

Some damage to shoreline terrestrial vegetation may result if an accident takes place during application. As in the case of aquatic plants, susceptibility of terrestrial plants to 2,4-D varies. Generally monocotyledonous plants and certain woody dicotyledonous species are quite resistant to the hormone-like effect of 2,4-D.

A pesticide may have additional adverse effects to animals that are related to its toxicity but are not generally observed as a short term direct effect. These are the ability of the pesticide to cause the growth of tumors (tumorigenicity), cancer (cancinogenicity) or to cause malformations in the offspring

TABLE C-1

TOXICITY OF 2,4-D

| Test animal | 2,4-D Formulation[1] | Dose or Concentration[2] | Remarks |
|---|---|---|---|
| Aquatic Organisms | | | |
| Bluegill sunfish | AA | 435-840 | 48 hr LC50 |
| | DMA | 166-458 | " " |
| | DDMCA | 1.5 | " " |
| | Acid and emulsifiers | 8.0 | " " |
| | IOE | 8.8-59.7 | " " |
| | PGBEE | 2.1 | " " |
| | BEE | 2.1 | " " |
| | BE | 1.3 | " " |
| | IPE | 0.8 | " " |
| | EE | 1.4 | " " |
| Channel catfish | DMA | 125 | 96 hr LC50 |
| Fathead minnows | DMA | 335 | " " |
| Fathead minnows | BEE | 2.1 | LC50 |
| Bass | DMA | 375 | 24 hr LC50 |
| " | " | 350 | 48 hr LC50 |
| Various Fish spp. | BEE granules | 40 & 100 ppa | No toxic effect Noted |
| *Anopheles quadrimaculatus* Mosquito larvae | BEE | 100 | LC30 |
| Benthic fauna | BEE granules | 40 & 100 ppa | No measurable toxic effect |
| Brown shrimp | BEE | 5.6 | 48 hr EC50[3] |
| | DMA | 2.0 | 48 hr EC10 |
| | PGBEE | 1.0 | 48 hr EC10 |
| Blue crab | DMA | 5.0 | 48 hr NE[4] |
| Eastern oyster | DMA | 1.0 | 96 hr NE |
| Longnose killifish | DMA | 15.0 | 48 hr NE |

CONTINUED

TABLE C-1 (Contd)

| Test animal | 2,4-D Formulation[1] | Dose or Concentration[2] | Remarks |
|---|---|---|---|
| Terrestrial organisms | | | |
| Rats, mice, guinea pigs, and rabbits | Various | 300-1000 | LD50 |
| White mouse | Na. | 375 | LD50 |
| Guinea pig | " | 1000 | LD50 |
| Rabbit | " | 800 | LD50 |
| White rat | " | 666 | LD50 |
| Monkey | " | 214 | Tolerated dose |
| Mice | " | 125 | Tolerated dose NE |
| Rats | " | 166 | " " " |
| Rabbits | " | 200 | " " " |
| Guinea pigs | " | 333 | " " " |
| White rock chicks | AA | 280 | Barely significant weight loss after 4 week oral dose. |
| White rock chicks | AA | 380 | Oral dose, all survived |
| White rock chicks | AA | 765 | Oral dose, all died |
| Broiler chicks | BEE | 600 | Oral dose, tolerated |
| " " | " | 900 | 24 hr LD50 |
| Rats | N.S. | 30 mg/kg/day | No ill effects over life span. |
| Dogs | N.S. | 10 mg/kg/day | No ill effects over life span. |
| Man | | | |
| Man | NaSalt(purified) | 2000 mg. | IV dose, no clinic evidence of toxicity. |
| Man | N.S. | 500 mg/day | NE 3 weeks. |
| | N.S. | 66 | IV dose, toxic reaction, 48 hr. recovery. |
| Man | IOE + Antabuse | 110+ 230 | Accidental poisoning 2 wk recovery. |
| Man | DMA | 900 | Suicide |
| Man | N.S. | 240 | Suicide |

TABLE C-1 (Contd)

| Test animal | Chemical | Dose or Concentration 2/ | Remarks |
|---|---|---|---|
| OTHER CHEMICALS | | | |
| Bluegill sunfish | Chlordane | 0.022 | 48 hr LC50 |
| " " | Dieldrin | | " " |
| " " | Endrin | | " " |
| Rats | Aspirin | 1500-2000 | LD50 |
| Mice | Salt(sodium chloride) | 3096 | LD50 |

TES

1/ List of 2,4-D formulation abbreviations

AA - Alkanolamine salt
DMA - Dimethylamine salt
DDMCA- Di - N, N-dimethylcocoamine salt
IOE - Isooctyl ester
PGBEE- Propylene glycol butyl ether ester
BEE - Butoxyethanol ester
BE - Butyl ester
IPE - Isopropyl ester
EE - Ethyl ester
Na Salt- Sodium salt
N.S. - Not stated in reference

2/ Unless otherwise noted, quantities are in mg/l in water for aquatic organisms and mg/kg dose for terrestrial organisms and man.

$EC_{50}$ - loss of equilibrium or death to 50%,
$EC_{10}$ - loss of equilibrium or death to 10%.

NE - No effects.

of animals exposed to the chemical (teratogenicity). To test for the possibility of these effects to animals and man, test animals are fed relatively large doses of the pesticide in question and the results observed. Innes, et. al., found that 2,4-D gave no significant indication of tumorigenicity after oral administration to mice (Innes, et. al., 1969).

The teratogenic potential of pesticides has recently received wide publicity because of a study that showed 2,4,5-trichloroacetic acid caused birth defects in test animals. More recent studies have shown that the high teratogenic activity of the 2,4,5-T was caused by a contaminate, 2,3,7,8-tetrachlorodibenzo-paradioxin (TCDD), which was produced in the manufacture of the herbicide (Wilson, 1973). Careful control of the manufacturing process has been shown to limit the TCDD content to acceptable limits. No detectable TCDD has been found in 2,4-D. The conditions necessary for the production of TCDD are not present in the manufacture of 2,4-D (Williams, 1972). Some 2,4-D ester formulations have been shown to be somewhat teratogenic when administered to test animals at high rates during certain periods of pregnancy.

Evaluation of teratogenicity is quite complicated. Dr. Wilson believes that just about any chemical which is administered in the proper dosage at the proper state of development to embryos of the proper species will cause disturbances in embryonic development. He cites many chemicals that man is exposed to quite often that have been shown to be teratogenic in one or more species of laboratory animal. Among them are salicylates (e.g., caffeine, nicotine), antibiotics (e.g., penicillin) and anesthetics (e.g., pentobarbitol). "These effects were usually seen only at doses well above therapeutic levels for the drugs, or above likely exposure levels for the environmental chemicals" (Wilson, 1973). The DMA formulation has not been shown to be teratogenic. It is usually considered to be less biologically active than the ester formulations. The residues of 2,4-D likely to follow application to aquatic plants and reach man in sufficient quantities to cause any effects is highly improbably (see Persistence).

The toxicity of 2,4-D to chicken and pheasant eggs was tested by Kopischke (1972). In this well-documented study, the isooctyl ester of 2,4-D was sprayed on pheasant and chicken eggs, another group of eggs was sprayed with diesel oil, and a third control group was sprayed with water. He found that there was no significant difference between the eggs sprayed with 2,4-D solution and those sprayed with water. None of the eggs sprayed with diesel fuel hatched. He found that the embryos in these eggs had died within 1 or 2 days after the application of oil. The isooctyl ester of 2,4-D has been shown to be more toxic than 2,4-D DMA (refer to Table M-1).

Fish nesting and spawning do not appear to be harmed by normal treatment of aquatic plants with 2,4-D. In ponds treated with 0.1, 0.5, and 1.0 ppm, nesting took place at the same time as control ponds. The number of fry taken with seines later in the season in the same ponds indicated that the number of offspring were about the same in all ponds (Cope, et. al., 1970).

Persistence. This is a term that indicates the relative length of time a pesticide remains in the environment in its applied form or is broken into its

f[illegible]t metabolities. "Two, 4-D is one of the most rapidly decomposed of all [illegible]icides . . but it cannot be considered absolutely non-persistent" ([illegible], 1970)

The persistence of 2,4-D in water is determined by various factors. The major factors contributing to the amount of residues in the water following application [illegible] (Gangstad and Averitt, 1971):

- R[illegible] of treatment.
- Frequency of application.
- Extent of dilution.
- Biodegradation by microoganisms.
- Metabolism by plants.
- Temperature and time.

The effects of the first three factors on residue levels are obvious. A standard application rate of four pounds acid equivalent per acre yielded: 1) a 115 parts per billion (ppb) decrease in residue for each 10 degrees F. increase in temperature above 60 degrees F. mean temperature, 2) a 58 ppb decrease in residue for each two-foot increase in water depth, and 3) a 53 ppb decrease in residue for each seven-day interval of time after treatment.

The activity of microorgranisms in the biodegradation of 2,4-D has been found to definitely influence the residue levels following application. Their ability to degrade 2,4-D, however, is dependent upon the microorganisms' being adapted to utilization of the 2,4-D. Faust and Aly (1964) found that bottom mud from a lake that had received previous 2,4-D treatment could degrade the chemical in 35 days. Mud that had come from a lake not previously treated with 2,4-D took 65 days to degrade the chemical. Hemmett and Faust (1969) found that the rate of degradation was increased substantially after the adaption of microorganisms to the use of 2,4-D. Initial applications to an aquatic system could therefore result in longer periods of detectable residues than would subsequent applications.

Two, 4-D is a plant hormone-like material. It is actively absorbed by plants and is metabolized by them. Studies have been performed which have shown "complete disappearances of 2,4-D in plants with partial metabolism within a week (Davis, 1970)."

Temperature and time effect the residue levels indirectly by their effects on microorganisms and plants processes, and by the currents' dilution effect over a period of time. The rate of degradation of 2,4-D by plants and microorganisms increases as the temperature rises. The residue levels decrease over time by the various methods described above (Hemmett and Faust, 1969).

In a recent study by Schultz (1973), residue levels of 2,4-D were monitored at three different geographical and ecological sites. Two, 4-D was applied at 2, 4, and 8 pounds per acre of the acid equivalent in ponds at each of the sites. Tables C-1 through C-8 are results of this monitoring program and reflect 2,4-D residue in water and fish following the herbicide application. These data, although showing a rapid decline in the 2,4-D residues, are not truly representative of residues that can be expected under normal

treatment conditions. The bodies of water are much smaller than those to be treated for alligator weed and primrose in the Charleston District. The dissipation of the chemical was therefore probably less than is usually encountered. The rate of treatment is similar to that proposed for target species; however, the total body of water was treated at these rates and not just the target plants. Most of the areas to be treated in the Charleston District have been treated previously so that microorganisms may have adapted to the utilization of 2,4-D. None of the test ponds had previously received 2,4-D treatment. Fish have been shown to avoid water containing 2,4-D (Duke, 1971; Hansen, 1969). The fish shown to contain the highest residues in this study were confined in live cages which received direct treatment without a plant buffer. Because of the differences cited above between this study and the proposed use of 2,4-D, the test data are probably not representative of residue levels that could be anticipated from implementation of the Aquatic Plant Control Program. In this study on the persistence of 2,4-D in slow moving water, it was shown that canals treated with 4 lbs/A and 8 lbs/A did not exceed the 0.1 ppm limit set for 2,4-D use in a potable water supply.

Movement within the Environment. This consideration is influenced by a pesticide's solubility in water, volatility, and potential for biomagnification. The DMA formulation, being very soluble in water may be transported from the application site by flowing water. Bartley and Hattrup (undated) found that 2,4-D was readily dissipated in the flowing water following overspray of water from canal bank applications. The highest concentration found after the application of 2.5 pounds of the active ingredient per acre was 2.3 parts per billion (ppb) Hattrup and Bartley, undated). The DMA formulation of 2,4-D is one of the least volatile formulations. This fact together with proper application methods to control spray drift minimize the air route as a means of 2,4-D movement. Biological magnification of 2,4-D has not been recorded in more than 20 years of extensive use (Davis, 1970). Some filter feeders have been found to accumulate the herbicide, but this accumulation decreases over a period of time. In field tests, Thomas and Duffy (undated) found that no residues remained in oysters after 21 days. In another treatment 0.7 mg/kg remained after 59 days. These treatments were made with the BEE of 2,4-D of 30 pounds acid equivalent per acre (Thomas and Duffy, undated). Schultz's data on 2,4-D residues in fish, (Tables C-6 through C-8) although not completely representative of initial residues to be expected, show that the material rapidly dropped to levels below the sensitivity of his equipment (Schultz, 1973). Additionally, his work showed that the distribution of the 2,4-D in the fish's body would preclude man's consumption of high levels of 2,4-D when eating fish flesh. Of the residues found in the fish, the greater amounts were in the organs removed prior to eating (Schultz, 1973).

In a study performed on bluegills and channel catfish, it was shown that uptake of 2,4-D DMA applied at 2 ppm is very small and the herbicide does not accumulate in the fish. The study also showed that the fish were unable to metabolize 2,4-D. The maximum concentrations of 2,4-D in the fish was within 24 hours of treatment (Sikka, 1976). A study on the fate of 2,4-D DMA in blue crabs showed no accumulation of the herbicide above the established tolerance limit for shellfish (1 ppm).

Rate and interval of application. The rate of application of a pesticide has a direct bearing on its toxic effect to animals and plants and the residues to be expected following treatment. Generally higher application rates tend to be more toxic and result in larger residue levels. Subsequent applications, prior to the complete dissipation and breakdown of the initial residues, increases the residue level and the likelihood of toxic effects to non-target animals and plants.

Studies were performed on the use of 2,4-D-BEE to control watermilfoil in TVA reservoirs. The conclusion reached was that when the herbicide was applied at the rate of 40 pounds acid equivalent per acre, and in some instances even 100 pounds, no recognizable significant adverse effects on aquatic fauna or water quality were produced (Smith and Isom, 1967).

The U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife (now Fish and Wildlife Service), monitored the application of 100 pounds per acre of 2,4-D-BEE by the U. S. Army Corps of Engineers to control Eurasian watermilfoil in Currituck Sound, North Carolina. The observations revealed "no acute adverse effects to fish and other organisms which could be attributed to the treatment". The report stated, "the estimated 95-plus percent initial reduction of Eurasian watermilfoil and the reestablishment and increase of native aquatic plants, which are preferred waterfowl foods, were considered by North Carolina biologists as being of significant benefit".

## DIQUAT

Diquat dibromide is very soluble in water and forms a very potent translocatable post-emergent herbicide. In neutral solutions the herbicide is very stable, however, in alkaline solutions it decomposes forming inactive colored complexes. The herbicide is rapidly absorbed and inactivated in the soil hence eliminating possible contamination of any shoreline vegetation.

Toxicity. Diquat has been shown to have an acute oral $LD_{50}$ rate of 400-440 mg/kg for rats. Diquat is considered to have a relatively low toxicity for fish and mammals. Table C-9 presents the $LC_{50}$ for various fish to diquat (David, 1971). No noticeable effect on shell growth of eastern oysters was noted on a 1.0 ppm exposure for 96 hours to diquat (Butler, 1963). After aquatic plant control activities with 0.5 ppm of diquat, the dying vegetation appeared to benefit certain benthic organisms, such as Oligochaeta (Tatum and Blackburn, 1962). White shrimp showed no noticeable effects in a 48 hour exposure to 1.0 ppm of diquat (Butler, 1963). An adverse response to plankton was noted by Tatum and Blackburn (1962) with a 0.5 ppm pond treatment with diquat, but the plankton quickly recovered.

Persistence. According to a study by Grzenda et. al., (1966) diquat applied to ponds at a rate of 2.5 ppm (five times that used in aquatic plant control) persisted in the water for 7 to 27 days without a buildup in the hydrosoil. Macek (1969) reported on persistence of diquat in fish that 50 percent of the chemical was lost in less than 3 weeks. Ultraviolet light rapidly degrades diquat in aquenous solutions. Diquat resists biological degradation in aquatic environments, but the presence of sorbents in the water in the

*Schultz, 1973

Table C-2

Physical characteristics of ponds in Florida, Georgia, and Missouri and concentrations of 2,4-D applied

| Pond | Surface area (acres) | Volume Acre feet | Volume Cubic meters | Depth (ft) Average | Depth (ft) Maximum | 2,4-D (mg/l) |
|---|---|---|---|---|---|---|
| Fla-Willow[1] | 0.60 | 2.54 | 3,134 | 4.23 | 7.0 | 0.174 |
| Fla-Shelter[1] | 0.43 | 1.45 | 1,789 | 3.37 | 6.0 | 0.436 |
| Fla-11-T[1,2] | 0.80 | 3.12 | 3,849 | 3.90 | 8.0 | 0.801 |
| Ga-0[3] | 1.30 | 7.30 | 9,007 | 5.60 | 11.0 | 0.000 |
| Ga-2[3] | 0.60 | 2.65 | 3,269 | 4.40 | 8.0 | 0.166 |
| Ga-4[3] | 0.90 | 2.70 | 3,331 | 3.00 | 7.0 | 0.490 |
| Ga-8[3] | 0.86 | 2.95 | 3,640 | 3.40 | 7.0 | 0.857 |
| Mo-15[4] | 0.073 | 0.166 | 204 | 1.65 | 4.5 | 0.000 |
| Mo-9[4] | 0.073 | 0.166 | 204 | 1.65 | 4.5 | 0.444 |
| Mo-28[4,5] | 0.162 | 0.368 | 452 | 2.50 | 4.0 | 1.002 |
| Mo-26[4,6] | 0.140 | 0.451 | 556 | 2.50 | 4.5 | 1.631 |

[1] Ponds had sandy bottoms covered with a muck layer 1-3 inches deep.

[2] Prior chemical treatment: 1969, 1.5 mg/l fenac, 1.0 mg/l $CuSO_4$

[3] Ponds had red clay bottoms (Piedmont Plateau).

[4] Ponds had bottoms of heavy colloidal clay.

[5] Prior chemical treatment: 1968, parathion-endrin mixture, concentration unknown.

[6] Prior chemical treatment: 1968, 0.002 mg/l malathion.

*Schultz, 1973

TABLE C-3

Residues of the dimethylamine salt of 2,4-D in water (mg/l) and hydrosol ([illegible]/kg) [illegible] from Florida ponds treated with 2.24, 4.48, or 8.96 kg 2,4-D acid equivalent per hectare (2, 4, or 8 lbs/acre)

| Treatment, pond, and sample | Days after treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 3 | 7 | 14 | 28 | 56 | 84 | 112 | 140 |
| 2.24 kg/ha (Willow Pond) | | | | | | | | | | |
| water | ND[1] | 0.125 | 0.025 | TR[2] | TR | TR | TR | TR | ND | ND |
| hydrosol | ND | TR | TR | 0.005 | TR | ND | ND | ND | ND | ND |
| 4.48 kg/ha (Shelter Pond) | | | | | | | | | | |
| water | ND | 0.155 | 0.172 | 0.048 | 0.005 | TR | ND | TR | ND | ND |
| hydrosol | ND | 0.014 | 0.014 | 0.010 | 0.010 | 0.007 | ND | TR | ND | ND |
| 8.96 kg/ha (11-T Pond) | | | | | | | | | | |
| water | ND | 0.312 | 0.345 | 0.025 | 0.005 | TR | ND | TR | ND | ND |
| hydrosol | ND | 0.033 | 0.046 | 0.008 | 0.013 | ND | TR | TR | TR | ND |

[1] ND - not detectable.

[2] TR - trace (less than 0.005 mg/l or kg).

*Schultz, 1973

TABLE C-4

Residues of the dimethylamine salt of 2,4-D in water (mg/l) and hydrosol (mg/kg) samples from Georgia ponds treated with 0, 2.24, 4.48, or 8.96 kg 2,4-D acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Treatment, pond, and sample | Days after treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 3 | 7 | 14 | 28 | 56 | 84 | 112 | 140 |
| No herbicide (Pond 0) | | | | | | | | | | |
| water | ND[1] | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| hydrosol | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2.24 kg/ha (Pond 2) | | | | | | | | | | |
| water | ND | 0.025 | 0.087 | 0.059 | 0.027 | TR[2] | ND | ND | ND | ND |
| hydrosol | ND | 0.018 | 0.008 | 0.010 | 0.006 | TR | ND | ND | ND | ND |
| 4.48 kg/ha (Pond 4) | | | | | | | | | | |
| water | ND | 0.233 | 0.390 | 0.400 | 0.050 | TR | ND | ND | ND | ND |
| hydrosol | ND | 0.024 | 0.018 | --[3] | TR | ND | ND | ND | TR | ND |
| 8.96 kg/ha (Pond 8) | | | | | | | | | | |
| water | ND | 0.617 | 0.692 | 0.395 | 0.008 | TR | ND | ND | ND | ND |
| hydrosol | ND | 0.026 | 0.040 | 0.042 | TR | ND | ND | ND | ND | ND |

[1] ND - not detectable. [2] TR - trace (less than 0.005 mg/l or kg). [3] Dashed line indicates no sample.

TABLE C-5

Residues of the dimethylamine salt of 2,4-D in water (mg/l) and hydrosol (mg/kg) samples from Missouri ponds treated with 0, 2.24, 4.48, or 8.96 kg 2,4-D acid equivalert per hectare (0, 2, 4, or 8 lbs/acre)

| Treatment, pond, and sample | Days after treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 3 | 7 | 14 | 28 | 56 | 86 | 112 | 147 |
| No herbicide (Pond 15) | | | | | | | | | | |
| water | ND[1] | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| hydrosol | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2.24 kg/ha (Pond 9) | | | | | | | | | | |
| water | ND | 0.104 | 0.108 | 0.102 | 0.050 | 0.017 | ND | ND | ND | ND |
| hydrosol | ND | ND | TR[2] | 0.009 | ND | ND | ND | ND | ND | ND |
| 4.48 kg/ha (Pond 28) | | | | | | | | | | |
| water | ND | 0.160 | 0.256 | 0.250 | 0.480 | 0.150 | ND | ND | ND | ND |
| hydrosol | --[3] | 0.011 | 0.012 | 0.005 | TR | ND | ND | ND | ND | ND |
| 8.96 kg/ha (Pond 26) | | | | | | | | | | |
| water | ND | 0.580 | 0.420 | 0.326 | 0.630 | 0.135 | ND | ND | ND | ND |
| hydrosol | -- | 0.170 | 0.170 | 0.091 | 0.068 | 0.005 | ND | ND | ND | ND |

[1] ND - not detectable. [2] TR - trace (less than 0.005 mg/l or kg). [3] Dashed line indicates no sample.

TABLE C-6

Residues of the dimethylamine salt of 2,4-D in fish from Florida ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| LMB-1 | 0 | ND[2] | | | |
| LMB-2 | 0 | ND | | | |
| CCF | 0 | ND | | | |
| LMB-1 | 1 | | 0.080 | 0.048 | TR[3] |
| LMB-2 | 1 | | | | ND |
| LMB-3 | 1 | | | | 0.008 |
| CCF-1 | 1 | | 1.075 | 0.340 | ND |
| CCF-2 | 1 | | | | ND |
| CCF-3 | 1 | | | | ND |
| BLG-1 | 1 | | 0.024 | 0.420 | 0.010 |
| BLG-2 | 1 | | | | TR |
| BLG-3 | 1 | | | | 0.012 |
| LMB | 3 | | ND | ND | ND |
| CCF | 3 | | ND | ND | ND |
| BLG | 3 | | ND | TR | ND |
| LMB | 7 | ND | ND | ND | ND |
| CCF | 7 | ND | ND | | ND |
| BLG | 7 | ND | ND | ND | ND |
| LMB-1 | 14 | ND | 0.036 | ND | 0.043 |
| LMB-2 | 14 | | 0.031 | | ND |
| LMB-3 | 14 | | TR | | |
| CCF-1 | 14 | | 0.029 | 0.050 | 0.024 |
| CCF-2 | 14 | | 0.032 | 0.012 | 0.102 |
| CCF-3 | 14 | | 0.012 | 0.039 | 0.094 |
| BLG-1 | 14 | ND | ND | 0.018 | ND |
| BLG-2 | 14 | ND | ND | 0.008 | ND |
| LMB-1 | 28 | | ND | ND | ND |
| LMB-2 | 28 | | ND | ND | TR |
| LMB-3 | 28 | | | ND | |
| CCF-1 | 28 | | ND | | ND |
| CCF-2 | 28 | | ND | ND | ND |
| CCF-3 | 28 | | ND | ND | ND |
| BLG | 28 | | ND | ND | ND |

*Schultz, 1973

TABLE C-6 (Cont'd)

(continued) Residues of the dimethylamine salt of 2,4-D in fish from Florida ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days After treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| LMB | 56 | | ND | ND | ND |
| CCF | 56 | | ND | ND | ND |
| BLG | 56 | | ND | ND | ND |
| LMB | 84 | | ND | ND | |
| CCF | 84 | | ND | | ND |
| BLG | 84 | | ND | ND | |
| LMB | 112 | | | | ND |
| CCF | 112 | | ND | ND | ND |
| BLG | 112 | | ND | ND | ND |
| LMB | 140 | | ND | ND | ND |
| CCF | 140 | | ND | | ND |
| BLG | 140 | | ND | | ND |

1 LMB - largemouth bass, CCF - channel catfish, BLG - bluegills.

2 ND - not detectable.

3 TR - trace (less than 0.005 mg/kg).

*Schultz, 1973

TABLE C-7

Residues of the dimethylamine salt of 2,4-D in fish from Georgia ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| LMB | 0 | ND[2] | | | |
| CCF-1 | 0 | ND | | | |
| CCF-2 | 0 | ND | | | |
| BLG | 0 | ND | | | |
| LMB | 1 | | ND | 0.014 | 0.022 |
| CCF | 1 | ND | ND | 0.043 | 0.008 |
| BLG | 1 | ND | ND | 0.024 | 0.044 |
| LMB-1 | 3 | ND | ND | ND | ND |
| LMB-2 | 3 | | | ND | ND |
| LMB-3 | 3 | | | ND | |
| CCF-1 | 3 | ND | ND | ND | ND |
| CCF-2 | 3 | ND | ND | ND | ND |
| BLG | 3 | | ND | ND | ND |
| LMB-1 | 7 | ND | ND | ND | ND |
| LMB-2 | 7 | | | ND | ND |
| LMB-3 | 7 | | | | ND |
| CCF-1 | 7 | ND | ND | ND | ND |
| CCF-2 | 7 | | | ND | |
| BLG | 7 | ND | ND | ND | ND |
| LMB-1 | 14 | ND | | ND | ND |
| LMB-2 | 14 | | | ND | ND |
| LMB-3 | 14 | | | ND | ND |
| CCF-1 | 14 | ND | | ND | 0.012 |
| CCF-2 | 14 | | | ND | |
| CCF-3 | 14 | | | ND | |
| BLG-1 | 14 | ND | | ND | 0.075 |
| BLG-2 | 14 | | | ND | ND |
| BLG-3 | 14 | | | ND | ND |

*Schultz, 1973

TABLE C-7 (Contd)

(Continued) Residues of the dimethylamine salt of 2,4-D in fish from Georgia ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| LMB-1 | 28 | ND | ND | ND | 0.010 |
| LMB-2 | 28 | ND | ND | ND | 0.005 |
| LMB-3 | 28 | ND | ND | | |
| LMB-4 | 28 | ND | | | |
| CCF-1 | 28 | ND | ND | ND | ND |
| CCF-2 | 28 | | ND | ND | |
| CCF-3 | 28 | | ND | ND | |
| BLG | 28 | ND | ND | ND | ND |
| LMB-1 | 56 | ND | ND | ND | ND |
| LMB-2 | 56 | ND | ND | ND | |
| CCF | 56 | ND | ND | ND | ND |
| BLG | 56 | ND | ND | ND | ND |
| LMB | 84 | ND | ND | ND | ND |
| CCF | 84 | ND | ND | ND | |
| BLG-1 | 84 | | | ND | ND |
| BLG-2 | 84 | | | | TR[3] |
| LMB-1 | 112 | ND | ND | ND | ND |
| LMB-2 | 112 | | | ND | |
| CCF | 112 | ND | ND | ND | ND |
| BLG | 112 | ND | ND | ND | ND |
| LMB-1 | 140 | ND | ND | ND | ND |
| LMB-2 | 140 | ND | ND | | |
| LMB-3 | 140 | ND | | | |
| LMB-4 | 140 | | | ND | |
| LMB-5 | 140 | | | ND | |

*Schultz, 1973

TABLE C-7 (Contd)

(Continued) Residues of the dimethylamine salt of 2,4-D in fish from Georgia ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| CCF-1 | 140 | | ND | ND | ND |
| CCF-2 | 140 | | ND | ND | |
| BLG-1 | 140 | | ND | ND | ND |
| BLG-2 | 140 | | | ND | |
| BLG-3 | 140 | | | ND | |
| BLG-4 | 140 | | | | ND |
| BLG-5 | 140 | | | | ND |

1 LMB - largemouth bass, CCF - channel catfish, BLG - bluegills.

2 ND - not detectable.

3 TR - trace (less than 0.005 mg/kg).

*Schultz, 1973

TABLE C-8

Residues of the dimethylamine salt of 2,4-D in fish from Missouri ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| CCF | 1 | | | ND[2] | ND |
| BLG | 1 | | | ND | ND |
| LMB | 1 | | | ND | ND |
| CCF | 7 | | | | ND |
| BLG | 7 | | | | ND |
| LMB | 7 | | | | ND |
| CCF | 14 | | | | ND |
| BLG | 14 | | | | ND |
| LMB | 14 | | | | ND |
| CCF-1 | 14 | | ND | | |
| CCF-2 | 14 | | ND | | |
| CCF-3 | 14 | | ND | | |
| CCF-4 | 14 | | ND | | |
| CCF-5 | 14 | | ND | | |
| BLG-1 | 14 | | ND | | |
| BLG-2 | 14 | | ND | | |
| BLG-3 | 14 | | ND | | |
| BLG-4 | 14 | | ND | | |
| BLG-5 | 14 | | ND | | |
| LMB-1 | 14 | | ND | | |
| LMB-2 | 14 | | ND | | |
| LMB-3 | 14 | | ND | | |
| LMB-4 | 14 | | ND | | |
| LMB-5 | 14 | | ND | | |

*Schultz, 1973

TABLE C-8 (Contd)

(Continued) Residues of the dimethylamine salt of 2,4-D in fish from Missouri ponds treated with 0, 2.24, 4.48, or 8.96 kg acid equivalent per hectare (0, 2, 4, or 8 lbs/acre)

| Species[1] and fish number | Days after treatment | Residues (mg/kg) in fish treated at -- 0 kg | 2.24 kg | 4.48 kg | 8.96 kg |
|---|---|---|---|---|---|
| CCF | 28 | | | | ND |
| BLG | 28 | | | | ND |
| LMB | 28 | | | | ND |
| CCF-1 | 28 | | | | ND |
| CCF-2 | 28 | | | | ND |
| CCF-3 | 28 | | | | ND |
| CCF-4 | 28 | | | | ND |
| CCF-5 | 28 | | | | ND |
| BLG-1 | 28 | | | | TR[3] |
| BLG-2 | 28 | | | | TR |
| BLG-3 | 28 | | | | TR |
| BLG-4 | 28 | | | | TR |
| BLG-5 | 28 | | | | TR |
| LMB-1 | 28 | | | | ND |
| LMB-2 | 28 | | | | TR |
| LMB-3 | 28 | | | | ND |
| LMB-4 | 28 | | | | ND |
| LMB-5 | 28 | | | | ND |
| CCF | 56 | | | | ND |
| BLG | 56 | | | | ND |
| LMB | 56 | | | | ND |

1 LMB - largemouth bass, CCF - channel catfish, BLG - bluegills.

2 ND - not detectable.

3 TR - trace (less than 0.005 mg/kg).

form of particulate matter would greatly influence diquat persistence in the aquatic environment. Although diquat has been found in muds of pools and ponds 4 years after application, no adverse effects on adult bluegills were noted at levels of diquat used for aquatic plant control. A study of six small golf course reservoirs involving control of submersed aquatic weeds showed that diquat dissipated to near nondetectable levels after 4 days. Two-thirds of the diquat disappeared after 1 day, indicating rapid absorption by aquatic vegetation, soil, and detritus. No detectable levels of diquat were found in crops irrigated with water containing diquat. Crops used in the experiement were potatoes, grain sorghum, soybeans, Romaine lettuce, carrots, and onions (Yeo et. al., 1971).

Movement. Some accumulation of diquat was found in sunfish exposed to sublethal concentrations in laboratory and field tests (Cope, 1965). Rainbow trout, however, did not concentrate diquat when exposed to water containing 1 ppm for 30 days (Cope, 1966).

## COPPER COMPLEXES

Elemental copper complexes (copper triethanolamine and copper ethylenediamine) plus diquat have been shown to be an effective combination to control egeria and hydrilla (Gangstad, 1976). A diquat-copper sulfate combination is more effective in controlling hydrilla than the diquat-copper complex combination, but is also more toxic to non-target organisms.

Phytoplankton and vascular plants (primary producers), and microcrustaceans and snails (primary consumers) are selectively killed by copper compounds (May, Hestand and Van Dyke, 1973). The various species manifest different susceptibilities to the herbicide's toxic effect, and they interact with fish life cycles. However, the small area to be treated relative to the area of existing aquatic habitat (Table C-10) precludes the probability that any perceivable damage to fish crops would occur.

A study on the use of a diquat and copper sulfate pentahydrate herbicide combination for hydrilla control was carried out by Yeo et. al. (1974). The copper was applied at a .3 ppm rate. An average of nine treatments showed the copper had dissipated to 47 ppb in 4 days. Two-thirds of the copper had disappeared after 1 day (Yeo et. al., 1974). Blackburn performed copper residue determinations after a hydrilla treatment with .75 ppm diquat plus 0.14 ppm copper (CUTRINE). The amount of copper in solution after two weeks was not significantly higher than the pretreatment levels (Blackburn and Gangstad, 1976).

## ENDOTHALL

Endothall is an organic contact herbicide that is useful in aquatic plant control due to its low toxicity to fish and fish-food organisms and its nonpersistent nature (Armstrong, 1974). Endothall has the empirical formula $C_8 H_{10} O_5$, a molecular weight of 186.06 and in its pure state is an off-white crystalline substance. It is not flammable and has a melting point of 144°C (Amchem, undated).

Table C-9

The $LC_{50}$ for various organisms to diquat, (David, 1971).

| Fish species | Exposure Time (hr) | $LC_{50}$ (ppm) | Source |
|---|---|---|---|
| Lake Emerald shiner | 1/ 24 | 15.5 | Swabey and Schenk, 1963 |
| Largemouth bass | 24 | 24 | Surber and Pickering, 1962 |
| Harlequin fish | 2/ 24 | 76 | Alabaster, 1969 |
| Rainbow trout | 3/ 24 | 90 | Alabaster, 1969 |
| Bluegill | 24 | 91 | Surber and Pickering, 1962 |
| Fathead minnow | 24 | 140 | Surber and Pickering, 1962 |
| Lake Emerald shiner | 1/ 24 | 180 | Swabey and Schenk, 1963 |
| Striped bass | 24 | 315 | Wellborn, 1969 |
| Rainbow trout | 48 | 12.3 | FWPCA, 1968 |
| Chinook salmon | 48 | 28.5 | Bond, Lewis and Fryer, 1959 |
| Chinook salmon | 48 | 28.5 | Bohmont, 1967 |
| Mallards | | 75,000 | Heath *et al*, 1970 |
| Pheasants | | 3,600-3,900 | Heath *et al*, 1970 |
| Coturnix | | 1,400-1,600 | Heath *et al*, 1970 |

1/ Medium hard water.

2/ Soft water.

3/ Tap water.

Table C-10

Toxicity of Copper on Aquatic Organisms

| Organism | Type Study | Toxicity (ppm) | Exposure Time | Reference |
|---|---|---|---|---|
| *Lepomis macrochisus* (bluegill) | Aquarium, Acute bioassay | 0.46 | 30 day | Suber (1962) |
| *Nemacheilus barbatulus* | Chronic bioassay | 0.2-0.3 | 24 hour | Mackereth and Smyly (1951) |
| *Lepomis macrochirus* (bluegill) | Aquarium, Acute bioassay | 0.74<br>0.94 | 4 day<br>2 day | Trama (1954) |
| *Nereis* sp. | Aquarium, Acute bioassay | 1.5<br>0.5 | 2 and 3 day<br>4 day | Raymont and Shields (1964) |
| *Carcinus maenas* (shore crabs) | Aquarium, Acute bioassay | 1-2 | - | Raymont and Shields (1964) |
| *Leander squilla* (prawn) | Aquarium Acute bioassay | 0.5 | - | Raymont and Shields (1964) |
| *Orconectes rusticus* (crayfish) | Continuous flow Acute bioassay | 3.0<br>1.0<br>1.0<br>1.0 | 4 day, intermolt adult<br>1 day, adult<br>6 day, juvenile<br>6 day, recently hatched | Hubschman (1967) |
| *Lebistes reticulatus* | Aquarium, Acute bioassay | 1.0 | - | Shaw and Grushkin (1967) |
| *Bufo valliceps* (tadpoles) | Aquarium, Acute bioassay | 0.1 | - | Shaw and Grushkin (1967) |
| *Daphnia magna* | Aquarium, Acute bioassay | 0.1 | - | Shaw and Grushkin (1967) |
| *Pimephales promelas* | Continuous flow Chronic bioassay | 0.43 | 4 day | Mount (1968) |
| *Salmo gairdnerii* | Aquarium, Acute bioassay | 0.4-0.5 | 2 day | Brown (1968) |
| *Lepomis macrochirus* (bluegill) | Aquarium Acute bioassay | 1.25 | 4 day | Cairns and Scheier (1968) |

Table adapted from Lawrence (undated) and EPA (1971)

Toxicity. Toxicity of endothall to mammals is given in Table C-11. No ill effects were noted in a 2 year chronic study on rats at 2,500 ppm and dogs at 800 ppm (Amchem, undated). In a study by Walker (1964) it was shown that changes in bottom fauna after treatment were due to ecological and water quality changes, rather than direct chemical influences. Lindaberry (1961) reported no significant changes in populations of various species of aquatic worms, clams, and various aquatic insects, but the levels of treatment were not given. It has been shown that endothall is more toxic to plants and fish in soft water (Yeo, 1964). Newly emerged honey bees required as much as 1,000 ppm of endothall to be toxic. The 96 hour $LC_{50}$ for amphipods is greater than 100 ppm and the 48 hour $LC_{50}$ for Cladocera is greater than 100 ppm. Table C-12 gives the toxicity of endothall to fish. As can be seen in the table, fishes can tolerate levels far greater (25 to 100) than those used for aquatic plant control activities (Armstrong, 1974).

Persistence. Hiltibran (1962) found that levels of 0.3 and 10.0 ppm of endothall could not be detected after 2.5 and 10 days, respectively. He determined that plant debris and mud help considerably in biodegradation of endothall. Walker (1963) reported that 50 percent of the endothall was lost from fish within three weeks. A study by Horowitz (1966) showed that the residual activity of endothall had disappeared after 14 days in moist soil.

Movement. Freed (1961) in a study of uptake and distribution of $C_{14}$ endothall in fish and plants concluded that due to extensive breakdown of the endothall molecule, it is doubtful if any of the herbicide remained. Walker (1962) found that at sublethal concentrations (0.06 to 0.3 ppm) bottom organisms concentrated endothall approximately 200-fold in 3 weeks.

TABLE C-11

Toxicity of Endothall to Mammals

| Organism | Endothall Formulation | $LO_{50}$ (mg/kg) | Route |
|---|---|---|---|
| Rat | Acid (technical) | 51 | Oral |
| Rat | HYDROTHOL$^{R}$ 47 (technical) | 206 | Oral |
| Rat | Dipotassium salt (formulation) | 125 | Oral |
| Rat | Disodium salt (formulation) | 182-198 | Oral |
| Rat | DESICATE$^{R}$ and ACCELERATE$^{R}$ (formulation) | 650 | Oral |
| Rabbit | DESICATE$^{R}$ and ACCELERATE$^{R}$ (formulation) | 250 | Dermal |

Adapted from Amchem, undated Endothall Technical Product Data Buletin 13c.

TABLE C-12*

Toxicity of Endothall to Fish (ppm)

| Species | TL 50 24 hours | TL 50 48 hours | TL 50 96 hours | Author Cited | Remarks |
|---|---|---|---|---|---|
| Salmo gairdneri | | | | 4 | No deaths at 10 ppm |
| Oncorhynchus shawyscha | 155 | 136 | | 1 | |
| Notropis sp. | | | | 4 | No deaths at 40 ppm |
| Pimephales promelas | | | | 4 | No deaths at 40 ppm |
| Pimephales promelas | 560-680 | 480-660 | 320-610 | 5 | |
| Morone saxatilis | | | 710 | 6 | |
| Micropterus salmoides | 560 | 320 | 200 | 5 | |
| Micropterus salmoides | 200 | 200 | | 1 | |
| Microptecus salmoides | | | | 4 | No deaths at 10 ppm |
| Lepomis macrochirus | | | 100 | 4 | |
| Lepomis macrochirus | 320-450 | 240-390 | | 5 | |
| Lepomis macrochirus | 428 | 268 | | 2 | |

1 Bond, Lewis, and Fryer, 1960

2 Davis and Hughes, 1963

3 Hughes and Davis, 1962

4 Lindaberry, 1961

5 Surber and Pickering, 1962

6 Wellborn, 1971

* Table adapted from Armstrong, 1974.

# appendix d

COST ESTIMATES

1. Treatment Methods. Costs for the various treatment methods are based on 1980 price levels. The annual costs are based on field treatment expenses to include equipment, maintenance, labor, chemicals and supplies. Administrative costs of Federal, State and local governments are not included.

a. Mechanical Harvesting. The costs of mechanical harvesting involves both harvesting and disposing of aquatic weeds. Total cost per acre includes three cuttings during the growing season and includes labor, equipment, maintenance and mobilization-demobilization. The estimated per-acre cost is:

| | | |
|---|---|---|
| 1. | Harvester operation | $180 |
| 2. | Disposal operation (Water transporter, conveyor, truck) | 180 |
| | Cost per acre | $360 |

(Plus a Capital cost of $160,000)

b. Rotovating. Rotovating may be used for spot treatment in isolated cases and a definite cost per acre was not estimated. Based upon the State of Washington Aquatic Plant Management Program, costs in the range of $600 to $700 per acre, plus a capital cost of $50,000 could be expected.

c. Hand Removal. Hand removal of alligator weed, primrose and elodea is only practical in small areas. The cost of this method, which would be based principally on labor, would be entirely dependent on the situation. No per acre cost has been estimated because of lack of data and limited probable use of this method.

d. Fiberglass Bottom Screen (Polyvinyl Chloride Coated Fiberglass Screen). The cost of fiberglass bottom screen is based on a purchase price of $0.20 per foot and an installation cost of $0.02 per foot. The per acre cost is:

| | |
|---|---|
| Fiberglass screen | $8,712.00 |
| Installation Cost | 871.20 |
| Total Cost per acre | $9,583.20 |

e. Chemical Treatment. The per-acre cost for chemical treatment includes expenses for labor (contractor) and chemicals.

(1) 2,4-D (DMA Liquid). Liquid 2,4-D (DMA) would be applied at a rate of 1 gallon per acre per application. Approximately three applications would be required throughout the growing season.

(i) Aircraft Application

| | |
|---|---|
| Chemical Cost | $60 |
| Application Cost | 30 |
| Total Cost/acre | $90 |

(ii) Boat Application

| | |
|---|---|
| Chemical Cost | $60 |
| Application Cost | 75 |
| Total Cost/acre | $135 |

(2) 2,4-D (BEE Granular). Granular 2,4-D (BEE) would be applied at a rate of 100 pounds per acre per application. Approximately two applications would be required throughout the growing season.

(i) Aircraft Application

| | |
|---|---|
| Chemical Cost | $120 |
| Application Cost | 40 |
| Total Cost/acre | $160 |

(ii) Boat Application

| | |
|---|---|
| Chemical Cost | $120 |
| Application Cost | 60 |
| Total Cost/acre | $180 |

(3) Diquat. Diquat would be applied at a rate of 2 gallons per acre per application. Approximately two applications would be required throughout the growing season.

(i) Aircraft Application

| | |
|---|---|
| Chemical Cost | $180 |
| Application Cost | 20 |
| Total Cost/acre | $200 |

(ii) Boat Application

| | |
|---|---|
| Chemical Cost | $180 |
| Application Cost | 50 |
| Total Cost/acre | $230 |

(4) Copper Complex. A chelated copper would be applied at a rate of 2 gallons per acre per application. Two applications would be applied throughout the growing season in conjunction with diquat and/or endothall (liquid), therefore, no additional application costs would be incurred.

| | |
|---|---|
| Chemical Cost | $60 |
| Total Cost/acre | $60 |

(5) Endothall (Liquid). Liquid endothall would be applied at the rate of 5 gallons per acre per application. Approximately 2 applications would be applied throughout the growing season.

(i) Aircraft Application

| | |
|---|---|
| Chemical Cost | $200 |
| Application Cost | 20 |
| Total Cost/acre | $220 |

(ii) Boat Application

| | |
|---|---|
| Chemical Cost | $200 |
| Application Cost | 50 |
| Total Cost/acre | $250 |

(6) Endothall (Granular). Granular endothall would be applied at the rate of 100 pounds per acre per application. Approximately 2 applications would be applied throughout the growing season.

(i) Aircraft Application

| | |
|---|---|
| Chemical Cost | $250 |
| Application Cost | 40 |
| Total Cost/acre | $290 |

(ii) Boat Application

| | |
|---|---|
| Chemical Cost | $250 |
| Application Cost | 60 |
| Total Cost/acre | $310 |

2. Estimated Total Acreage of Target Species in South Carolina. A noxious aquatic plant reconnaissance survey of South Carolina was made in 1979 and supplemented during the summer of 1980. Estimated acreages of the three target species occurring in waters of the state follows:

a. Brazilian Elodea. Approximately 30,000 acres of Brazilian elodea infested waters occur in the state, including 26,000 acres in Lake Marion and 4,000 acres in rivers, streams and reservoirs.

b. Water Primrose. Approximately 6,000 acres of water primrose occur in Lake Marion with another 3,000 acres occurring in various rivers, streams and reservoirs.

c. Alligator Weed. Approximately 900 acres of alligator weed infested waters occur in the state in various rivers, streams, reservoirs and backwaters.

# appendix e

## EPA ESTABLISHED TOLERANCES FOR SELECTED HERBICIDES IN POTABLE WATER

Tolerances established for pesticides in potable water:

| Chemical | Tolerance (ppm) | Citation 21 CFR |
|---|---|---|
| Diquat | 0.01 | 193.160 |
| 2,4,D | 0.1 | 193.100 |
| Endothall | 0.2 | 193.180 |
| Copper | 1.0 | 193.90 |
| Dalapon | 0.2 | 193.105 |

Tolerances have been granted on the basis of use of these chemicals as follows:

| Chemical | Site/Pest/Use |
|---|---|
| Diquat | An interim tolerance of 0.01 part per million is established for residues of the herbicide diquat in potable water (calculated as the cation) resulting from the use of its dibromide salt to control aquatic weeds in canals, lakes, ponds, and other potential sources of potable water. |
| 2,4,D | Tolerances are established for residues of the herbicide 2,4-D (2,4-dichlorophenoxy-acetic acid) as follows: 0.1 part per million (negligible residue) in potable water. Such residues may be present therein only:<br>a. as a result of the application of the dimethylamine salt of 2,4-D to irrigation ditch banks in the Western United States in programs of the Bureau of Reclamation; cooperating water user organizations; the Bureau of Sport Fisheries, U.S. Department of Agriculture; and the Corps of Engineers, U.S. Department of Defense.<br>b. as a result of the application of the dimethylamine salt of 2,4-D for water hyacinth control in ponds, lakes, reservoirs, marshes, bayous, drainage ditches, canals, rivers and streams that are quiescent or slow moving in programs of the Corps of Engineers or other Federal, State or local public agencies. |
| Endothall | An interim tolerance of 0.2 parts per million is established for residues of the herbicide endothall (7-oxabicyclo 2.2.1 heptane-2, 3-dicarboxylic acid) in potable water from use of its potassium, sodium, di-N,N-dimethylalkylamine, and mono-N-N-dimethylalkylamine salts as algacides or herbicides to control aquatic plants in canals, lakes, ponds, and other potential sources of potable water. |
| Copper | A tolerance of 1 part per million is established in potable water for residues of copper resulting from the use of algacides or herbicides basic copper carbonate (malachite), copper sulfate, and copper triethanolamine to control aquatic plants in reservoirs, lakes, ponds, irrigation ditches, and other potential sources of potable water. |
| Dalapon | A tolerance of 0.2 parts per million is established in potable water when present therein as a result of the application of dalapon sodium magnesium salt mixtures to irrigation ditch banks in the Western United States. (Note: this chemical cannot be used in Florida.) |

# appendix f

LETTERS OF COMMENT
ON THE REVISED DRAFT
ENVIRONMENTAL IMPACT STATEMENT

United States Department of Agriculture
Soil Conservation Service
1835 Assembly Street, Room 950
Columbia, South Carolina
29201

April 29, 1980

William W. Brown
Colonel, Corps of Engineers
District Engineer
P. O. Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

We have reviewed the Revised Draft Environmental Impact Statement and General Design Memorandum No. 3 for the Cooperative Aquatic Plant Control Program for South Carolina.

The EIS has adequately covered the proposed Plant Control Program. We support this program. Page 9 of the EIS discusses Land Resource Areas. Recently a sixth has been delineated. See the attached page.

There are two points which we feel could strengthen the Design Memorandum.

(1) Page 7, 10.3, second paragraph discusses periodic inspections. To insure effectiveness of the herbicide application program perhaps inspection should be mandatory.

(2) Page 6, Plan of Operation discusses the survey and plan of action. Perhaps starting near the top of basins (headwaters) to try to eradicate the problem and work downstream would be a systematic approach to the problem.

We appreciate the opportunity to review and comment on this program. It is greatly needed.

Sincerely,

G. E. Huey
State Conservationist

Attachment



SCS-AS-1
10-79



DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA GEORGIA 30333

May 28, 1980

District Engineer
U.S. Army Engineer District, Charleston
P. O. Box 919
Charleston, South Carolina 29402

Dear Sir:

We have reviewed the Draft Environmental Impact Statement (EIS) for the Cooperative Aquatic Plant Control Program for South Carolina. We are responding on behalf of the U. S. Public Health Service and are offering the following comments for your consideration.

We agree that excessive growths of aquatic plants may have to be controlled. However, we have some concern regarding the use of 2,4-D in the aquatic environment. Until more information is known about its chronic effects upon nontarget food chain organisms and potential long-term health risks, the use of 2,4-D should be minimized and if possible restricted to highly infested areas where other control measures are non-effective.

We believe that other control measures such as physical, mechanical and particularly biological controls should be further encouraged. Where access is obtainable and where fragmentation will not threaten uninfested waters, harvesting could remove the plants from the aquatic system and preclude re-entry of decomposed products providing nutrients for future vegetative growth. An integrated control effort which combines both mechanical harvesting and chemical treatment can often be effective. 2,4-D is often most effective when applied to vegetation which is rapidly growing. This rapid growth condition can occur after mechanical harvesting. Would such an integrated control effort using both mechanical harvesting and chemical treatment be applicable in certain infested areas for the target vegetation?

The use of rotovating methods, containment booms, suction dredge, hand removal, bottom screens, fragment barriers and spread prevention programs to control the target vegetation from spreading may be other measures worth considering. The possible forage and compost benefits of the target vegetation should be assessed in the EIS. Other potential uses of the target vegetation should be considered.

The EIS should describe the potential beneficial and adverse impacts of using 2,4-D upon sensitive ecosystems, potable water supplies, irrigation waters, fisheries, and wildlife. The effectiveness and proposed application rate of 2,4-D in controlling each of the target vegetation (roots, stems and leaves) in both quiet and turbulent water areas should be noted. This is important because G. E. Smith (Hyacinth Control Journal, 9(1):23-25, 1971) has found 2,4-D to be ineffective in controlling certain vegetation along main river and lake areas where downstream flow or turbulent water rapidly dissipates the herbicide. Please indicate the rate of reinfestation and/or regrowth for each of the target vegetation after application of chemical treatment.

# United States Department of the Interior

OFFICE OF THE SECRETARY

Southeast Region / Suite 1412 / Atlanta, Ga. 30303
Richard B. Russell Federal Building
75 Spring Street, S. W.

May 29, 1980

ER 80/335

District Engineer
U.S. Army Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Sir:

We have reviewed the revised draft environmental statement and GDM No. 3, Cooperative Aquatic Plant Control Program, South Carolina, as requested by your letter of April 9, 1980. We offer the following comments.

Specific Comments

Page 4, Adverse Impacts

No mention is made that an eradicated nuisance plant could be replaced by an even more obnoxious species.

Page 8, Chemical Control

Experiments to develop selective control of aquatic vegetation for management should be addressed. The Elodea in Lake Marion could be managed to improve sport fishing opportunity. Strips of vegetation could be eliminated to provide boat access while retaining adjacent strips to harbor sport fish. The pattern selected should be aligned with the depths needed for boat access, standing timber, and other controlling physical conditions. A feasibility study should be undertaken by the Corps of Engineers and coordinated with the South Carolina Division of Wildlife and Freshwater Fisheries and the Fish and Wildlife Service.

Consideration should be given to measures for harvesting treated vegetation to minimize the buildup of decaying plant detritus.

Page 12

We note some variation of your information to that of our records. We are enclosing our federally listed species for South Carolina and their general distribution as of August 1979. No critical habitat for any listed species has been designated in South Carolina.



According to the General Design Memorandum, the application rate will be 4 pounds of 2,4-D active acid equivalent per acre of vegetation. Is this an effective application rate in the proposed infested areas? Too little 2,4-D may stimulate vegetative growth (Final EIS, State of Washington, Aquatic Plant Management Program, October 1979). We have seen references where recommended application rates for 2,4-D were 20 pounds or more active acid equivalent per acre of vegetation in aquatic plant control programs.

A description of 2,4-D's persistence in the water column following treatment should be provided as well as the following topics: its breakdown products, biological accumulation, acute and chronic toxicity, carcinogenicity, teratogenicity, and mutagenicity.

We note that other aquatic vegetation species will be controlled with herbicides other than 2,4-D. The EIS should identify these herbicides and describe their effectiveness and potential environmental effects in the areas to be used.

We appreciate the opportunity to review this EIS. Please send us one copy of the final document when it becomes available.

Sincerely yours,

Frank S. Liselia, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Bureau of State Services

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30308

June 5, 1980

4SA-EIS

Colonel William W. Brown, USA
Corps of Engineers, Charleston District
P. O. Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

We have reviewed the revised Draft Environmental Impact Statement (DEIS) and General Design Memorandum #3 for the Cooperative Aquatic Plant Control for South Carolina. We are in basic agreement with your ascertion that the program should result in an overall improvement in water quality in those areas affected by the targeted weed species. However, some possible impacts of the program on water quality and other environmental parameters have not been considered or are incompletely addressed.

The DEIS states that the release of bound nutrients during decay of aquatic weeds may result in phytoplankton blooms. These blooms may stimulate zooplankton population growth and subsequently increase total fish production. However, the negative impacts of these blooms such as depletion of water column oxygen levels by algal decomposition, odor and taste problems, and reduction in aesthetic value were not discussed. Algal blooms may interfere with the intended uses of water in much the same way as the aquatic weeds themselves. A comparison of the positive and negative aspects of blooms would be valuable in determining cases where attempts should be made to foster this condition.

Mechanical methods of aquatic weed control were generally dismissed as "slow, expensive and inefficient." However, this technique can be an important adjunct to chemical aquatic weed control and should be included wherever feasible. It has the attendant benefit of removing weeds from a site where it has been determined that accumulation of nutrients in the water column or organic buildup in bottom sediment would be undesirable.

Pages 12 and 13

*The fact that the excess vegetation is non-native seems irrelevant as the basis for determining noxious vegetation. Removing it will not assure replacement with desirable vegetation but a likely replacement of vegetation causing the same problems. Any potential for establishing desirable waterfowl plants would be mainly fortuitous. Skills to manipulate a rooted aquatic vegetation is highly desirable, but has not yet developed as a dependable management technique in a large area.*

Pages 12-15, Environmental Effects

This section fails to discuss the monitoring of water quality in conjunction with application of highly toxic herbicides such as ortho diquat. The decay of a large number of plants could result in oxygen depletion of significant magnitude to cause a fish kill. It would appear reasonable to enlist the aid of South Carolina Department of Health and Environmental Control to monitor water quality in all critical situations.

Page B-2

No herbicide is listed for control of Elodea. Yet large areas are reported to occur in Lake Marion (26,000 acres) and 240 miles of *rivers and streams. Also the General Design Memorandum* No. 3 lists diquat, salts of endothall, copper compounds and other herbicides to be used for Elodea, etc., control. These aspects should be covered in the statement.

Thank you for the opportunity to review and comment on this statement.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

Enclosure

The DEIS acknowledges that the use of aquatic herbicides can cause unavoidable damage to beneficial, non-target vegetation. The destruction of such beneficial plants may indirectly impact aquatic life and waterfowl by reducing vegetation types which provide cover or grazing opportunities. This is even more likely if aeral application of herbicides is anticipated. Based on the Corps' experience in Florida and Alabama, the extent of the off-site, non-target damage should be discussed in the Final Statement.

While we do not criticize the use of 2,4-D as the chemical of choice, there are other herbicides presently registered by EPA for aquatic control. Four of these, including 2,4-D, have received tolerances for use in potable water in the Eastern United States. (See attachment.)

Insufficient discussion is given to the possible health consequences both short and long term of higher levels of herbicides in potable water or food crops. Special precautions must be directed toward the use of chemicals around potable water supplies, especially near intakes. The maximum containment level (MCL) for 2,4-D in finished drinking water is 0.1 mg/L, so stringent measures may be necessary. We advise that the South Carolina Department of Health and Environmental Control (DHEC) and/or local water supply utility be contacted regarding this project for their expertise and assistance.

The DEIS makes the general statement that since aquatic herbicides are generally absorbed by plants and mud, bioaccumulation has not proved to be a problem in their use. Nevertheless, the environmental mobility characteristics of the specific herbicide intended for use here, i.e., the amine salt of 2,4-D, should be given. The EIS should indicate whether this herbicide is readily absorbed/retained by aquatic weeds; will it be released in the water column upon plant decomposition, and is there a possibility of bioaccumulation or bioagnification effects with its use.

The DEIS contends that the use of aquatic herbicides, in general, results in little or no effect on phytoplankton, macroinvertebrate and crustacean communities. However, the Final Statement would be improved by specific details about the impact of these communities by the amine salt of 2,4-D.

The title of the document indicates this is a "cooperative" program. Yet the actual participants in the "cooperative" program other than Charleston District are not identified. The exact responsibilities of the Charleston District, as well as specific examples of coordination and cooperation with State and local authorities would be benificial.



On the basis of our review a rating of LO-2 was assigned, i.e., we have no significant environmental objections to the program; however, some additional information is requested. If you wish to discuss the matter in greater detail, Dr. Gerald Miller, EIS Review staff, will serve as point of contact.

Sincerely yours,

John E. Hagan III

John E. Hagan, III
Chief, EIS Branch

Enclosure

South Carolina Department of Health and Environmental Control



2600 Bull Street
Columbia, S.C. 29201

April 16, 1980

Colonel William W. Brown
Charleston District, Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

RE: Cooperative Aquatic Plant Control Program - South Carolina
Revised Draft Environmental Impact Statement

Dear Colonel Brown:

The staff of the Division of Vector Control, DHEC, have examined the above referenced EIS and accompanying design memorandum.

We are happy to see that mosquitoes have been given some consideration as an environmental impact.

We agree with the necessity to control aquatic weeds and feel that the EIS makes a fair presentation of the alternatives and their impacts.

Sincerely,

L. A. Williams, Jr.

L. A. Williams, Jr., Director
Division of Vector Control

LAW/SML/ch

"The South Carolina Water Resources Commission" welcomes this aquatic plant management program and believes that the project will aid in managing an important water resource problem. This agency is intensely interested in the aquatic weed problem as it relates to surface water use. The proposed project is greatly needed and is consistent with this agency's plans and policies. We submit the following comments and suggestions in regard to this project.

1.) The State should be included in the planning and management of the aquatic plant control program, as well as in field operations.

2.) An appropriate State agency should be designated to coordinate the involvement of other State agencies in this program and to represent all water use interests which may benefit from this project.

3.) This project is directly related to the interests and area of responsibility of the Water Resources Commission, which includes the protection and utilization of the State's surface water resources. This agency requests to be kept informed of activities conducted under this project and to be included in, at a minimum, the planning phase of the aquatic plant management program. We wish to have the opportunity to contribute to problem assessment, management strategy, and to establishment of control priorities.

4.) There is some confusion concerning the areas of the State that will be eligible for aquatic plant control. In the Design

Memorandum, page 3, part 6.1, it states -- "Project work may be performed in any river, lake, stream or waterway of the State..." -- and in the RDEIS, page 3, second paragraph, it states -- "Control operations would be confined to the area between the fall line and the upper limits of saltwater intrusion...". The status of the area northwest of the fall line should be clarified.

5.) It is suggested that the project include a program of water quality monitoring, where chemical treatment is used, to document post-treatment levels of dissolved oxygen and other pertinent parameters.

6.) There may be some circumstances under which mechanical control is desirable. Perhaps this control method should not be completely excluded from the project.

7.) We encourage the use of research funds to develop biological control methods for aquatic weed control. These funds should be made available to academic institutions in the State for biological control research.

# State of South Carolina

## Office of the Governor

RICHARD W. RILEY
GOVERNOR

OFFICE OF EXECUTIVE POLICY AND PROGRAMS

April 30, 1980

Major Milton Hunter
Deputy District Engineer
Charleston District Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Major Hunter:

Thank you for the opportunity to comment on the proposed program for controlling noxious aquatic plants in South Carolina waters.

There are several points which we feel deserve mention. The first of these is that herbicides should not be used near sensitive habitats such as rookeries or spawning grounds, nor should they be used in areas where they may be washed into nontarget locations such as marshes.

Application of chemicals should be made in such a way that massive quantities of decaying plant material do not deprive fish of their oxygen supply.

We would urge you to explore innovative alternatives to chemical control such as the use of biological agents where appropriate and the conversion of harvested aquatic weeds to ethanol.

Finally, we would like to see a portion of the aquatic plant control funds devoted to public education. In many cases, exotic aquatic plants become a problem when they are introduced to an area without natural controls. The public should be made aware of the problems associated with the introduction of exotic species.

Thank you once again for the opportunity to review this proposal.

Cordially,

Ben H. Gregg, Jr.

Ben H. Gregg, Jr.
Director

BHG/jbv

Division of Natural Resources, Post Office Box 11450, Columbia 29211

**PRT**

| | |
|---|---|
| MEMO TO: | Buddy Jennings, Director<br>Planning & Development Division |
| FROM: | John Reid Clonts, State Parks Naturalist<br>Division of State Parks |
| DATE: | May 5, 1980 |
| SUBJECT: | Cooperative Aquatic Plant Control Program - South Carolina. |

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I have reviewed the information forwarded to me by your office relating to the cooperative venture by the U. S. Army Corps of Engineers and the S. C. Department of Agriculture to control aquatic weeds on South Carolina's waterways. The project seems to be consistent with the plans and policies of the Department of Parks, Recreation, and Tourism; however, I have some concern about the proposed chemical controls, especially the use of 2,4-D. To minimize the adverse impact of the use of 2,4-D, I would propose that the chemical be applied only during cooler weather. Other than that, I have no personal objection to the proposal.

I am returning the DOA Form 7 to you for your signature.

J. R. C.

JRC/jgw

Attachment

South Carolina Department of Parks, Recreation & Tourism
Suite 113, Edgar A. Brown Building • 1205 Pendleton Street • Columbia, South Carolina 29201

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S. C.

P. O. Box 11,669
Capitol Station 29211
803 — 758-5816

May 6, 1980

Colonel William W. Brown
District Engineer
Charleston District
Corps of Engineers
Post Office Box 919
Charleston, S.C. 29402

Re: Revised Draft Environmental Impact Statement and General Design Memorandum No. 3, Cooperative Aquatic Plant Control Program, South Carolina

Dear Colonel Brown:

We have reviewed the revised Draft Environmental Impact Statement for the above referenced project.

We note on page 4 that consideration has been given to cultural resources. Please note that there are many National Register properties in the lowlands and coastal areas as well as the uplands.

Since the project involves aquatic plant control activities restricted to the water zone, we concur with your opinion that no National Register properties or underwater cultural resources would be affected by control activities.

The Federal procedures for the protection of historic properties (36CFR800) require that the Federal agency official in charge of a federally funded or licensed project consult with the appropriate State Historic Preservation Officer. The procedures do not relieve the Federal agency official of the final responsibility for reaching an opinion of his own as to whether or not historic values have been adequately taken into account in allowing the project to proceed. The opinion of the State Historic Preservation Officer is not definitive, either by law or by established Federal procedure. In reaching a conclusion of his own, the Federal agency official may well wish to consult other experts.

Sincerely,

Charles E. Lee
State Historic Preservation Officer

CEL/dkn

UNIVERSITY OF SOUTH CAROLINA
COLUMBIA, S C 29208

INSTITUTE OF ARCHEOLOGY AND ANTHROPOLOGY
(803) 777-8170

May 8, 1980

Mr. Elmer C. Whitten, Jr.
State Clearinghouse
Division of Administration
1205 Pendleton Street
Columbia, SC 29201

RE: Control #11-2007-0

Dear Mr. Whitten:

We have reviewed the "Revised Draft Environmental Impact Statement" on the "Cooperative Aquatic Plant Control Program in South Carolina" prepared by the U. S. Army Engineer District, Charleston, South Carolina. This program affects water courses throughout the state. Although no immediate direct impacts may obtain for cultural or archeological resources (pg. 11), some of the long-term consequences of chemical or herbicidal additions to the water (pg. 8) and fluctuating water levels (pg. 8) may adversely affect site (and artifact) preservation.

Unfortunately, no thorough land and river archeological survey has been conducted for the entire state of South Carolina. The Statewide Archeological Inventory Files, maintained by the Institute of Archeology and Anthropology, University of South Carolina, have over 5,000 recorded sites: prehistoric and historic, land and underwater. Some counties, some drainages have been examined more systematically than others. However, unless a field inspection has been made, the presence and condition of sites which may be potentially eligible for the National Register of Historic Places cannot be determined.

Our long-term goal is to inventory all the sites in South Carolina. Sites located in vulnerable positions along eroding river banks or subject to shoreline fluctuations on lakes are of particular concern. To help further our efforts, we request that if any evidence of archeological remains are discovered during this program, the Institute be notified immediately so that a record can be made.

Sincerely,

Veletta Canouts
Archeologist

Robert L. Stephenson
Director and State Archeologist

VC:daw



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STATE OF SOUTH CAROLINA
OFFICE OF THE STATE AUDITOR
P O BOX 11333
COLUMBIA
29211

EDGAR A. VAUGHN, JR., CPA
STATE AUDITOR

June 9, 1980

Mr. John Carothers
U. S. Army Engineer District, Charleston
P. O. Box 919
Charleston, S. C. 29402

Dear John:

Re: Revised Draft Environmental Impact Statement Cooperative Aquatic Plant Control Program

Enclosed are the comments that have been received on the referenced statement from the Water Resources Commission, the State Archeologists, and the Department of Parks, Recreation and Tourism. You should have already received comments directly from the Department of Archives and History and Mr. Ben Gregg in the Governor's Division of Natural Resources.

Thank you for the opportunity to comment on the draft statement.

Sincerely,

Elmer C. Whitten, Jr.
State Clearinghouse

Enclosures

ECWjr:cs

AD-A152 081 STATE OF SOUTH CAROLINA COOPERATIVE AQUATIC PLANT CONTROL PROGRAM(U) CORPS OF ENGINEERS CHARLESTON SC CHARLESTON DISTRICT NOV 80 2/2

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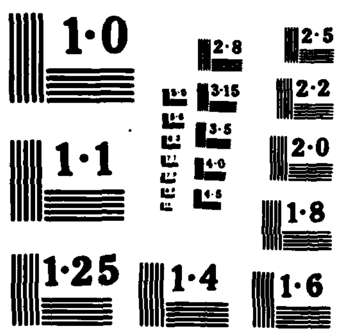
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# appendix g

## COASTAL ZONE MANAGEMENT ACT CONSISTENCY DETERMINATION

COOPERATIVE AQUATIC PLANT CONTROL PROGRAM

STATE OF SOUTH CAROLINA

DETERMINATION OF CONSISTENCY WITH THE SOUTH CAROLINA

COASTAL MANAGEMENT PROGRAM

1. This activity is consistent with the South Carolina Coastal Management Program. In the process of making the determination of consistency, the Cooperative Aquatic Plant Control Program was reviewed in light of the broad goals of the Coastal Management Program and with particular attention given to the policies established for navigation, wetlands, public recreation, agriculture, and wildlife.

2. The program is authorized by the 1958 River and Harbor Act, as amended, by Section 302 of Public Law 89-298, 89th Congress, approved 27 October 1965. If funding is made available, field operations would begin during the spring 1982.

3. Project Description: The proposed program provides for a comprehensive plan to control noxious aquatic plants within the state waters of South Carolina in the interest of navigation, flood control, agriculture, fish and wildlife, public health, and other related purposes. Target species include alligator weed, Brazilian elodea, and water primrose. Alligator weed would be controlled by an integrated program involving insects and herbicides. Brazilian elodea and water primrose would be controlled by herbicides. Herbicides to be used are approved by EPA for use on the target species in South Carolina waters. Other treatment methods acceptable under the recommended plan include mechanical harvesting and fiberglass bottom screens. The selection of treatment methods for individual sites would be the responsibility of the Corps of Engineers in cooperation with the local sponsor.

4. A more complete discussion of the project features, and impacts can be found in the March 1980 General Design Memorandum No. 3, and Revised Draft Environmental Impact Statement, Cooperative Aquatic Plant Control Program, State of South Carolina.

# appendix h

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APPENDIX H

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